POWER PLANT ENGINEERING

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Handling Coal and Ashes at the Pusey & Jones Power Plant

DETAILS OF SYSTEM EMPLOYING BUCKET CONVEYOR WHICH GIVES GOOD RESULTS IN SHIPYARD PLANT. BY HENRY J. EDSALL

"THE BEST POWER PLANT of any shipyard on the Atlantic Coast," was the expression used by one of the Emergency Fleet Corporation officials, after looking over this plant. This is a well-deserved compliment, for the plant as a whole is a fine example of a first-class modern power plant.

The Pusey & Jones Shipyard, at Gloucester, is a combination of the yards of the Pennsylvania Shipbuilding Corporation and the New Jersey Shipbuilding Corporation, the yards of which adjoin each other, and both of which were purchased by the Pusey & Jones Corporation about the end of 1917, at the time when the greatest pressure was being brought to bear by the Government, in order to speed up the shipbuilding program to the top-notch.

The Pennsylvania Shipbuilding Corporation had been purchasing power from the Public Service Corporation of New Jersey and the New Jersey Shipbuild-

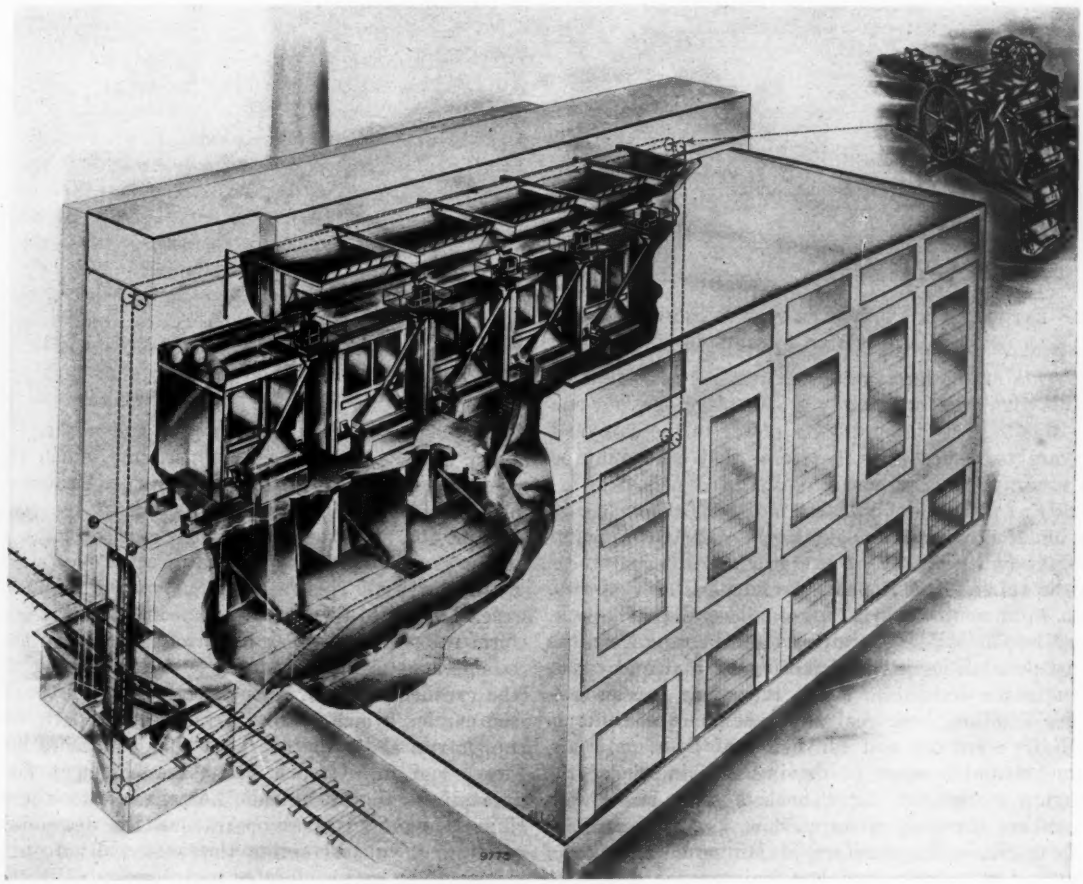


FIG. 1. GENERAL ARRANGEMENT OF COAL AND ASHES HANDLING EQUIPMENT

ing Corporation had also planned to purchase power from this corporation, but the power demand had increased so greatly that the Public Service Corporation had just about reached the limit of the capacity of its equipment, and as it was impossible to obtain large generating units and all the other additional equipment required to add materially to the output of a large central electric station, the Public Service Corporation advised the Pusey & Jones Co. to build a power plant of its own. This, of course, meant considerable delay in bringing the shipbuilding capacity of the yard up to its maximum, and inspired the engineers to the most strenuous efforts to complete the plant, so as to supply the badly needed electric power in the shortest possible time.

The Lewis and Roth Corporation of Philadelphia was employed as engineer to design the whole power plant, and finally took the contract to build it. Estimates were made overnight, sub-contracts were limited to the shortest time, and everything possible was done to get the generators running in the minimum length of time.

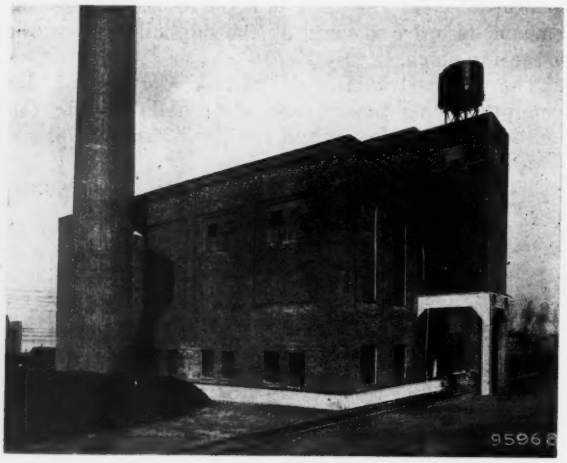


FIG. 2. EXTERIOR VIEW OF POWER PLANT, SHOWING ASHES POCKET AT ONE END OF BUILDING

In spite of the hurry, the fact was not lost sight of that this plant was not simply a temporary one, but one which was to keep on supplying power to the shipyard for years to come, and, therefore, that it should be built according to best modern practice.

The three factors of greatest importance in coal and ashes handling equipment might be stated as simplicity, reliability and economy of operation. As a matter of fact, the third factor depends largely on the first two, for an equipment which is not simple and reliable will not be economical to operate. After investigating the various possibilities in the handling of coal and ashes, the engineers decided to adopt the single carrier system for handling both coal and ashes, one machine to do all the elevating and conveying of both materials, one motor and one set of driving machinery for the conveying equipment, large buckets with large well-oiled rollers traveling along at slow speed on standard T-rail tracks, and, therefore, a minimum amount of power and attendance and low maintenance cost, with few spare parts to be carried in order to be prepared for any emergency.

The building is built with concrete foundations and brick walls, and with ample windows for light and air. The boiler room is on the south side and generator room on the north side, the former being 170 ft. long by 52 ft. wide, and the latter 150 ft. long by 49 ft. wide. The boilers face toward the generator room, and the north side of the boiler room is carried up higher in a monitor that provides the required space for the overhead bin. This bin is of the suspension bunker type, with the weight carried by longitudinal girders along the upper edges, the curved plates for the lower part of the bin body being hung from these girders. The longitudinal girders are framed into cross girders and the cross girders are supported on columns extending down to concrete foundations. On one side the columns are set in the partition wall between the boiler room and the generator room, and on the other side they act also as supports for the boilers. The roof trusses over the boilers and the roof trusses over the generator room extend from these columns to the outside walls. The overhead bunker is about 100 ft. long and holds 250 tons of coal when full. The building is built mostly above ground, the basement floor level being only one foot below the yard level, and the boiler room and generating room operating floors are respectively 16 ft. and 19 ft. above the basement floor. In the boiler room, the basement provides for the ash pits, air ducts, lower run of the carrier and various other accessories, and the basement of the generating room is used for pumps and condensers.

There are five 415-hp. Stirling boilers, or a total of 2075 hp. normal rating. These boilers are placed 21 ft. 6 in. center to center, so as to give spaces of about 5 ft. 6 in. between them. The boilers are all equipped with gravity underfeed stokers, which are automatically fed by spouts from the overhead bin, and each spout is equipped with a 100-lb. automatic scale, so that the amount of coal delivered to each boiler is automatically registered by the scale. This gives an accurate record of the coal used by each unit, without any possibility of human error, as there is where the weight has to be recorded, or separated for the different units, by an operator, and without any attendance such as is necessary in the operating of a traveling weighing hopper.

The railroad track runs close to the east end of the boiler room, and the track hopper, into which the coal is discharged from the railroad cars, is located underneath the track, a little to the south of the center of carrier, and an apron feeder runs from the track hopper to the crusher, which is located directly over the center of the carrier. This feeder transfers the coal from the track hopper to the crusher automatically and at a uniform rate, which is very important if the crusher is to be operated to best advantage. After passing through the crusher, the coal goes directly into the buckets of the carrier, which follows a rectangular path with the upper run above the overhead coal and ashes bins, the lower run in a trench below the basement floor, the ascending run just outside the railroad track and passing through the ashes pocket and the descending run coming down just inside the west wall of the boiler house. The coal is elevated and distributed in the overhead bin by the carrier buckets, the discharging of the buckets being accomplished by a movable tripper run-

ning on T-rail tracks, just below the upper run of the carrier.

The ash pits are built the full width of the stokers and with bottoms sloping at an angle of 30 deg., so as to form chutes leading to the lower run of the carrier. As the center of the carrier is about 9 ft. from the front wall of the ash pits, the space in between is bridged by sloping steel chutes, or aprons, down which the ashes slide to gratings in the floor, over the carrier. At the lower end of each apron there is a gate, so that the ashes will not get into the carrier until it is desired to send them up to the ash bin. At present the ashes are dumped three times a day through the dump plates at the rear of the stokers, and, as soon as convenient, the carrier is started, and they are raked down the chutes and fed through the gratings to the lower run of the carrier, and taken up into the overhead ashes bin. The overhead ashes bin is built to conform with the rest of the building, with two concrete columns outside the railroad track and a concrete floor, and brick walls above this concrete floor, one of the walls being the end wall

FIG. 3. INTERIOR VIEW LOOKING WEST, SHOWING OVERHEAD BIN, AUTOMATIC SCALES, SPOUTS TO STOKERS AND DESCENDING RUN OF CARRIER AT END OF BUILDING

of the building. This makes a very neat and permanent design. A concrete well is built inside the ashes pocket for the ascending run of the carrier.

The coal handling equipment has a capacity of 60 tons of coal an hour, and the carrier will handle an equivalent volume of ashes. With a coal consumption of 120 tons per day, the coal can be handled in 3 or 4 hr., so that there is more than ample time for handling both the coal and ashes in the daytime. It can be readily appreciated, from the picture showing the ashes chutes in the basement, that the feeding of the ashes to the carrier is very easily done. They simply have to be raked down the chutes to the gratings, through which most of them pass without breaking, and it is a very easy matter to break any of the clinkers which are too large to go through the openings. The capacity of the carrier is so large that the ashes are taken care of very quickly and with a minimum amount of labor. When the writer visited the plant recently the generators were turning out about 3000 kw., and the total plant force consisted of five men, two men as stoker operators, one man to look after coal and ashes handling equipment, and the chief engineer and his assistant in the generator room.

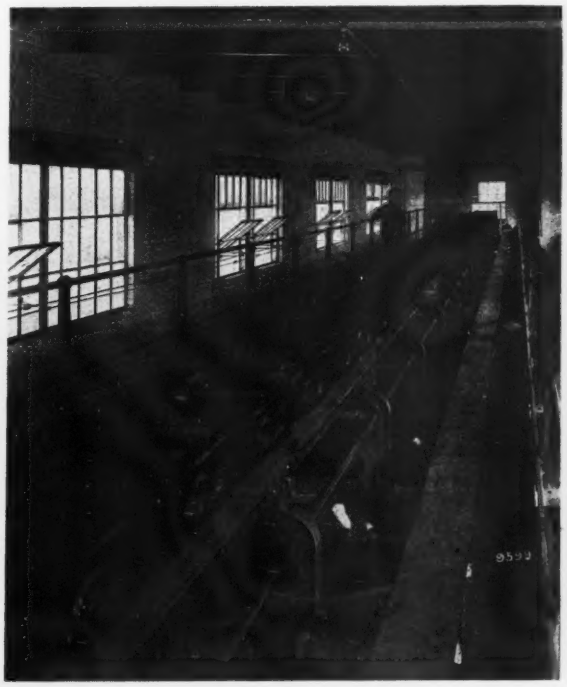


FIG. 4. UPPER HORIZONTAL RUN OF PIVOTED BUCKET CARRIER, SHOWING EMPTY BUCKETS

Only two motors are required for the conveying and crushing equipment, a 7½-hp. motor for the conveyor and one of 15 hp. for the crusher and feeder.

Details of Machinery

THE TRACK hopper is 12 ft. square and made of ¼-in. steel plate, properly braced and stiffened with steel angles. It is hung from the track beams, which support the railroad tracks over the pit, these beams being double 15-in. I-beams resting on the pit walls at the ends and supported at the center of the pit by a 24-in. I-beam running across the pit and supported on the walls. The part of the pit where the track hopper is located is 9 ft. 6 in. deep, and where the crusher is located, with the lower run of the conveyor underneath it, the pit is 12 ft. 9 in. deep.

The apron feeder, which feeds the coal from the track hopper to the crusher, serves as a bottom plate underneath the track hopper, so that the coal rests directly on the feeder apron. It is also confined by sides along the apron so that it rides along and falls over the end into the crusher. The apron speed is only 11 ft. a minute. The apron itself is made up of corru-

gated steel pans, attached to a double strand of steel-strap roller chain, each link of which is 9 in. pitch, and which has a 3¼-in. single flanged cast-iron roller at each joint. The chain joints are bushed with case-hardened steel bushings to give large joint bearing surfaces of hard metal and, therefore, long life to the chain.

The crusher is a standard two-roll coal crusher, with rolls 28 in. in diameter by 24 in. long, the teeth being of such a size and arranged in such a manner that coal is crushed to a size of about 1½ in. and under. These crusher rolls are geared together by means of spur gears with especially long teeth, and one of the rolls has relief springs, so that it can move back in case some foreign substance gets between the rolls. A belt drive is used to connect the motor with the crusher driven shaft, the possible slip of the belt serving as an

FIG. 5. ASHES CHUTES DELIVERING TO LOWER RUN OF CARRIER, WHICH TRAVELS IN A TRENCH BELOW THE BASEMENT FLOOR. ASHES CAN BE DELIVERED IMMEDIATELY TO CARRIER OR ALLOWED TO REMAIN ON CHUTES UNTIL A CONVENIENT TIME TO SEND THEM UP TO THE OVERHEAD BIN

additional protection in case of any unusual strains from foreign substances getting between the rolls. The apron feeder is driven by means of a chain drive from one of the crusher roll shafts. Both the crusher and apron feeder are supported by means of steel framework resting on the concrete work of the pit, the frame for the feeder including angle iron tracks along which the rollers of the chain roll, thereby supporting the apron and the coal resting on it.

The pivoted bucket carrier is a standard 24-in. by 18-in. machine, i.e., the chains are 24 in. pitch, this being also the length of each bucket, and the buckets are 18 in. wide. When traveling along horizontally, or at a slight incline, the buckets are continuous and have overlapping lips to prevent material from leaking between them as it is fed into them. Both the chains and buckets are malleable iron, the chain joints being fitted with high carbon steel pins and case-hardened steel bushings, thereby furnishing ample bearing surface in the joints to reduce the bearing pressure and give long life. Running on the outside of the bushing at each joint is a 6-in. single-flanged roller, cored out to make a large oil reservoir in the interior of the roller, and then a felt washer fitted into a circular slot, next to shaft, so that the oil feeds slowly through the felt washer to the bushing, and then through a large slot in the bushing to the pin. The supply of oil lasts for three or four weeks, so that it is a simple matter to keep the joints well oiled, and this fact, together with the excellent wear-resisting materials of the pins and bushings, makes the joints last a remarkably long time, and in addition to this, when the pins and bushings do wear, they are small parts which can be easily replaced at comparatively small expense. Even where the chains are exposed to abrasive grit and dust the construction is such that the wear is very slow. The oil, coming from the inside of the roller and oozing out towards the outside, tends to force the dirt out of the joints, rather than into them, and tends to form an oil-seal which keeps out the dirt. The chains are also protected at feeding points by curved steel guards which form regular hoods over them, these guards usually extending the full length of the lower run.

The rollers of the chain travel along on 16-lb. T-rail tracks on horizontal and inclined runs, and they are confined between double T-rail tracks on both sides on vertical runs. The rails are supported throughout on cast-iron rail chairs, the ones on the lower run being bolted direct to the concrete pit floor, the ones on the upper run to small cross channels resting on I-beam stringers, and the ones on the up and down runs being attached either to the walls of the building or to the steel casing. These tracks serve to confine the chains and buckets to their intended path of travel, and everything is so carefully designed and the speed is so slow that the possibility of a breakdown is very remote.

In this case the lower run of the carrier is located in a trench underneath the basement floor, the trench being covered by diamond steel checkered floor plates, resting on small I-beams and on the walls at the sides of the trench, this arrangement leaving the floor clear without obstruction, so that the attendant who handles the ashes can move around at will and get up close to the ashes chutes when he is raking them down. The lower run is horizontal throughout most of the length, but is dipped down at the end where it goes underneath the crusher. The turn shafts at each end of the lower run are supported on cast-iron stands bolted directly to the concrete foundations. The bearings at the descending end are adjustable to take up any slack due to stretch in the chains. The ascending run of the carrier is enclosed in a No. 10 steel casing from the ground level up to the bottom of the ashes bin. The descending run is guarded by steel guards for a short distance above the operating floor. The upper run of the carrier, over the coal and ashes bins, is supported on steel framework built up from the bins, the carrier being set at the proper height for piling the coal in a peak over the top of the coal bin, thereby filling the bin

heaping full and taking full advantage of the maximum holding capacity. The discharger for discharging the coal from the buckets moves along on another pair of rails, the moving being accomplished by letting the buckets push it along when traveling in the same direction that the buckets travel, and the movement in the opposite direction being by means of a small wire cable attached to the discharger frame, and winding up on a hand winch at the end of the run. A separate fixed discharger is used to deliver the ashes to the ashes bin. This discharge can be dropped down so that it will not engage the buckets when not handling ashes.

The ashes bin is really deeper than necessary, and a vertical chute is used to deliver the ashes into the bin up to the proper level, so that they will not be piled too deep for the strength of the side walls. The 16½ by 43-in. rotary gates, with cast-iron sides and cast-iron chutes, are used to deliver the ashes from the bin to the railroad cars. These gates are opened by means of a rack and pinion arrangement with a hand chain and wheel for rotating the pinion shaft. This chain hangs down to within easy reach of the ground. The carrier is driven by means of a silent chain drive from the motor to the first counter shaft, and then a double-spur gear reduction with two counter shafts for connecting to the head shaft. The large spur gear on the head shaft and the pinion meshing with it are the equalizing type to eliminate irregular motion always accompanying long pitch steel chains, i.e., the rotation of the driving sprockets is made irregular, so as to counteract the irregular motion of the long pitch chains and give a uniform rate of motion to the carrier.

Underneath the coal bin are the five spouts to the five stoker magazines, each spout being fitted with a standard 100-lb. automatic scale. These scales operate entirely automatically and record the number of 100-lb. loads which pass through them. The reciprocating agitators, which are part of the scales and which prevent the coal from clogging where it feeds into the scale hopper, are driven from a single line shaft, connected to a 2-hp. motor, and there are clutches at each scale which throw out automatically when the scale is at rest, i.e., when it is waiting for the coal in the spout underneath to feed down to the stoker magazine and make room for another charge.

Footwalks are provided along the upper run of the carrier and along by the automatic scales, and ladders are provided for getting up to the top of the overhead bins and for going down into the pits. In most cases it is better to provide a stairway up to the top of the bin, as it has been proved many times by experience that the more accessible machinery is, the better care it is given.

This machinery was not the cheapest which could have been installed to do this work, but it is about the simplest arrangement which could be used, and it requires a minimum amount of attendance to operate and maintain it, as well as a minimum amount of power in its operation. Everything is rugged and well built, so that repairs and delays will be few and far between, provided it is given ordinary care. It will undoubtedly prove a better investment in the end than a cheaper equipment, and it will be readily appreciated that it will help to keep the general efficiency of the plant up to the top-notch.

Steel Chimneys

By Mark Meredith

At Messrs. Firth's Sheffield works there are four tall chimneys in use in connection with the new open-hearth steel works. These stacks are each some 150 ft. high and 10 ft. in diameter. They are made of steel for carrying off smoke and fumes from boiler furnaces and represent a departure which has made rapid headway during the last 20 yr., and from reasons of economy they have been adopted at most of the newly-constructed works. In normal conditions of trade they can be built at much less cost and more quickly than similar erections in brick or stone; they occupy less base space, and when done with are worth a good sum of money as scrap. The cost of dismantling a lofty brick stack exceeds, in the great majority of instances, the market value of the material recovered, and the fact remains the spectacle which often puzzles passengers in a railway train of a tall chimney, apparently in perfect condition, standing intact and solitary, on the site of a vanished factory or works. The steel stack, consisting as it does of large sections fastened together, may be taken apart comparatively easily and quickly and with little damage to the material. War conditions, however, are unfavorable to the builders of steel chimneys, because, owing to the inflated prices, they cost almost as much as, or more than, those of brick. Nevertheless, the advantage of rapid construction has induced those erecting new works to win time as an important consideration to specify the modern type. The utilitarian advantages of the innovation are certainly gained at the expense of picturesqueness. To most people the steel chimney will be an eyesore; whereas it is not difficult to discover a considerable degree of beauty in the outlines of a slender round or hexagonal column of brick rising in a taper to a height of a couple of hundred feet.

A consideration which should weigh in deciding between a steel and a brick chimney is the future of the smoke question. The war has probably brought us much nearer the ideal of a smokeless atmosphere as far as industrial processes are concerned. The elimination of waste has made tremendous strides of late years, and as smoke is simply wasted fuel, the time cannot be far distant when means will be discovered of using it for the production of energy. In such an event the discarded steel stacks could be turned into ready money whereas the others would be practically worthless.

Twenty teachers will be furnished by the board of education of Philadelphia to go into the industrial plants of the city to conduct free classes for the instruction of the foreign element, according to an announcement yesterday by Supt. John P. Garber. Selections from the teaching force will be made shortly. Commenting on the move, Superintendent Garber said:

"All that is required of the employers of foreign labor is that they designate the time and place best suited to them and we will do the rest."

The installation of convenient belt hooks where machines are shut down for long periods is advisable. With the belt idle, the saving in fuel and belting is considerable, and the cost of the hooks is trivial.

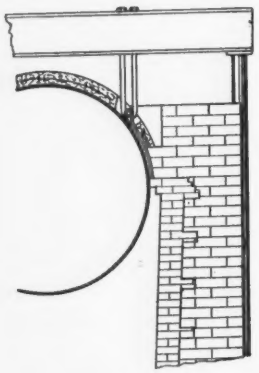
FUEL CONSERVATION LETTERS

By Joseph Harrington, Formerly Administrative Engineer for the State of Illinois

Boiler Coverings. Letter No. 10

BY boiler coverings we understand any material placed on the outside of a boiler setting for the purpose of preventing infiltration of air, radiation of heat, or both. It is primarily a brickwork covering.

These two functions are radically different, both in character and effect on the general efficiency of the plant. The radiation loss is very largely a constant quantity, and in brick-set boilers, operating at normal capacities, will probably not exceed two or three per cent. This, however, is a never-ending loss and amounts in the course of a year to a very substantial sum. Fortunately it is a loss which can be very nearly completely eliminated. It is imperative, therefore, that it must be stopped; and inasmuch as the first cost is the whole cost there is little excuse for any delay in preventing this waste.

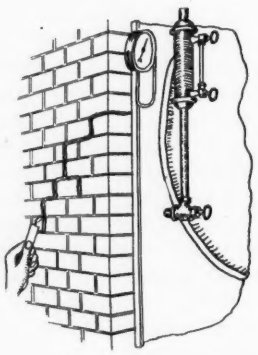


Obviously, the method of procedure is to cover the boiler with some insulating material, such as plastic asbestos putty, magnesia block, asbestos sheet or moulded insulation; or similar substance.

The covering should be fire-proof in character, able to withstand high temperature without disintegration and fairly substantial. A 2-in. coating of asbestos cement built up on a wire net support and then covered with a cloth, which in turn is given two coats of paint, makes one of the most effective insulating coatings known. It is not expensive and experience shows that it pays for itself in a very few months.

Infiltration takes place in any setting, but is much greater in brick settings and vastly greater in those which have become cracked and broken around the joints and openings. It is entirely possible for as much air to leak through the side walls of a boiler as that which passes through the fuel bed. Such a loss is very heavy and is also continuous. Again, there is little excuse for any such condition and no time should be lost in giving your boiler settings a good coat of some plastic insulating material that will expand with the setting and form an air-tight jacket through which little or no air can pass.

There are a number of very satisfactory boiler coverings of this kind on the market, readily applied and obtainable at moderate cost. There is scarcely any investment in the boiler room that pays greater returns than this. As in the case of the insulation, the first cost is practically the entire cost; and dividends are paid just as long as the coating is kept in a fair state of repair.



The practical effect that will be noticed by the engineer upon the adoption of these two efficiency devices is a very marked reduction in the volume of his stack gases and an increase in his stack draft. On account of a heavy infiltration having the effect of cooling the stack gases, it will also have the effect of reducing the stack draft. Many cases of deficient draft are due solely to the excess volume of air which the stack is called upon to carry away. Every pound of air leaking into the setting absorbs a substantial amount of heat and chills the boiler a noticeable amount. It is a direct and complete loss of sufficient magnitude to be noticed in the coal bills.

The measure of infiltration is the difference in the CO_2 content of the gases between the furnace and the uptake. For ordinary well-built new boiler settings a drop of $2\frac{1}{2}$ per cent in the CO_2 is normal. In the case of a tight asbestos or steel covered setting, $1\frac{1}{2}$ per cent is normal. I have never seen continuous averages of less than .05 per cent drop. On the other hand, the old dilapidated setting will frequently account for 6 per cent.

Do not rest content until your loss is not more than 2 per cent.

Let every owner immediately spend the money required to prevent these two constant losses and the beneficial effect will be noticed at once.

Cool Drinking Water Systems

ICE AND MECHANICAL COOLING EQUIPMENT; PIPING ARRANGEMENTS; CALCULATIONS. BY CHARLES L. HUBBARD

A SYSTEM of distribution for pure cool drinking water in the works of an industrial plant or in other large buildings like hotels, office buildings, etc., is an important matter, especially during the summer months. While the purity of drinking water is, of course, of first importance, a proper temperature is also necessary in order to secure the most satisfactory results.

Warm or tepid water does not quench the thirst, and, furthermore, gives one a feeling of fullness and discomfort, while on the other hand, water which is too cold chills the stomach and is generally considered harmful, especially if taken in generous quantities in hot weather or when the body is overheated.

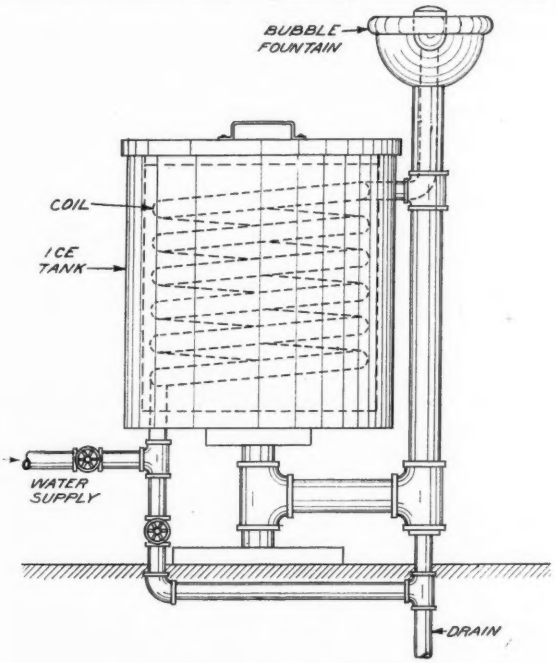


FIG. 1. ICE TANK FOR COOLING WATER

Water which is cooled directly by the addition of ice is to be avoided, for no matter how pure the water may be, any harmful substances which the ice may contain are added to it in the process of melting.

SYSTEMS OF WATER COOLING

TWO SYSTEMS of cooling are adapted to work of this kind, depending upon the size of the plant and other local conditions which may be present.

The first of these makes use of ice as the medium of cooling, while the other employs mechanical refrigeration.

The first method is more especially adapted to buildings of small or medium size, where the number of drinking fountains is not great, so that a cooler may be located at each, or centrally located and connected with a limited number of fountains in such a manner that the exposed surface in the connecting pipes is not excessive. A cooling system of this kind is less expensive to install than one employing mechanical refrigeration, especially in a finished building where it is desired to have the distributing pipes concealed. A typical cooler and fountain of this kind is shown in diagram in Fig. 1, and may be made up from standard fittings and appliances which may be found upon the market.

A galvanized iron or copper tank, insulated upon the outside, is fitted with an inside brass coil, either extending around the perimeter or in the form of a spiral laid on the bottom of the tank. This coil is connected with city pressure or with a house tank, as most

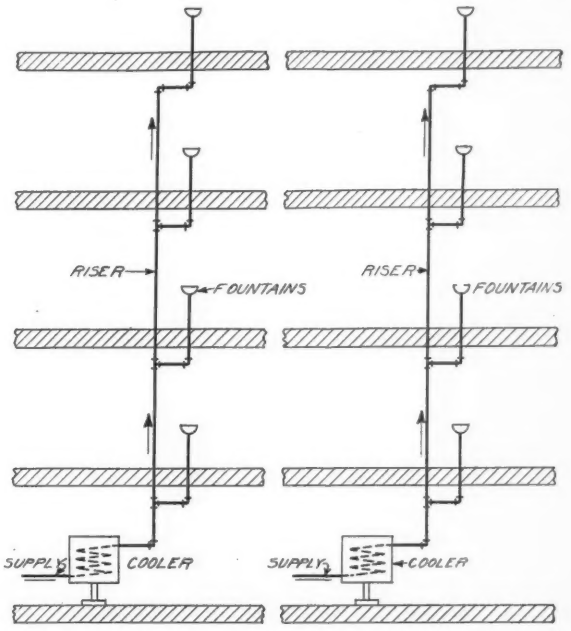


FIG. 2. DRINKING WATER SYSTEM FOR BUILDING USING ICE TANK FOR COOLING

convenient, and ends in a bubble drinking fountain provided with a self-closing control valve. The body of the tank, inside the coil, contains a cake of ice surrounded with water. The coil is of such length as to provide sufficient storage capacity so that the movement of water through it is slow enough to produce the necessary cooling effect. Two or more drinking fountains may be connected with the same cooler, provided the distance is not too great.

The best arrangement of this kind, and one especially adapted to industrial plants, is to carry single risers up through the building at intervals, and providing a cooler at the bottom of each (see Fig. 2). By insulating the riser, comparatively little waste of either water or ice will be noticed. When elevator accommodations and other local conditions are such that the ice can be as easily distributed to the tanks on the upper floor as in the basement, the arrangement may be reversed, as shown in Fig. 3.

In this case the water is admitted by means of a ball-cock to a small tank with which the upper end of the coil connects, and a circulating pipe is carried from the bottom of the supply riser or drop to the tank.

Any motive power for producing circulation brought about in this way is very slight and is easily overcome by the frictional resistance of the pipe and fittings. For a vertical riser without horizontal runs of piping, however, it is worth considering. When it is desirable to concentrate the cooling for an entire building in a single tank or cooler (see Fig. 4), it will be necessary to provide a continuous circulation through the supply system. Under these conditions it will be necessary to

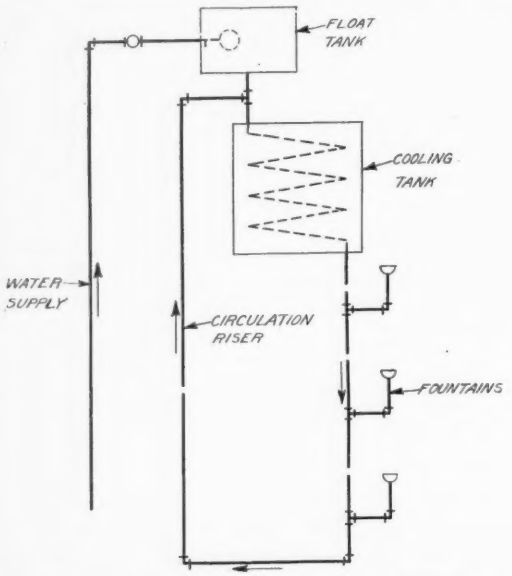


FIG. 3. DRINKING WATER SYSTEM WITH COOLING TANK ON UPPER FLOOR

employ a small centrifugal pump. In this case the water is supplied through a ball-cock to a small tank located 10 or 15 ft. above the highest fixture, and circulation is produced through a coil submerged in a tank of ice water located in the basement.

In any system of extensive distribution of the kind shown in Fig. 4, the greater part of the cooling effect required will be that necessary to offset the heat absorbed by the piping system rather than in cooling the water actually drunk. This greatly increases the consumption of ice, so that in buildings containing a large number of occupants it is usually more satisfactory to employ mechanical refrigeration than to handle the required amount of ice.

In a large plant employing about 800 operatives a system of drinking water distributed through approximately 4000 ft. of mains required over 1½ tons of ice per day of 8 hp., which is in line with the recommendations made above for mechanical refrigeration in cases of this kind. This not only works out as a matter of convenience but of economy of operation in many cases.

An instance was reported not long ago where drinking water was provided for 1000 men in a large manufacturing plant at an annual cost of $5 each when using ice. By changing over to mechanical refrigeration, at a total cost of $9000, the operating cost was reduced to $1.82 per man per year.

The general arrangements for mechanical refrigeration are practically the same as for cooling by ice, with the exception of the construction and operation of the cooler itself. In this case the cooling medium is inside the coil, while the water passes through the tank on the outside; all other details as regards circulating pump, piping arrangements, float tank, etc., are the same as for ice cooling in the general arrangement shown in Fig. 4.

A typical layout for a system of water cooling and distribution employing mechanical refrigeration is shown in diagram in Fig. 5. The refrigerating machinery, with the exception of the cooling tank, is outside the scope of the present article but has been shown in order to make the diagram more complete.

This arrangement of tanks and piping constitutes what is known as the open system, as compared with the closed system shown in Fig. 4.

In this case the cooling tank, instead of being entirely filled with water under pressure, contains only enough to submerge the ammonia coil, this level being maintained automatically by means of a small auxiliary tank connecting with it and containing a ball-cock which admits water as needed from the source of supply.

The circulating pump takes its supply from the lower part of the cooling tank and forces it through the

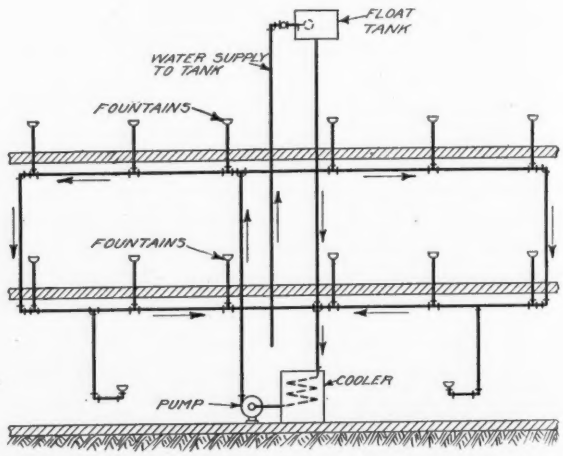


FIG. 4. SINGLE WATER COOLER FOR ENTIRE BUILDING

distributing system, as indicated by the arrows. The surplus forced into the supply main, over that drawn from the faucets, is returned to the cooling tank through a relief valve set to maintain from 5 to 10 lb. pressure per square inch on the system.

This arrangement is used only where the pressure on the water supply is not sufficient to produce the desired head at the fixtures on the upper floors, and in cases where distilled water or spring water is used, which is drawn into the cooling tank without pressure. When the drinking water is taken from the city mains under ample pressure to supply the highest fixtures, then the closed system shown in Fig. 4 is used, as the power for pumping is less in this case, being only that necessary to overcome the frictional resistance in the

pipes, the water being lifted to the upper floors by the pressure in the mains.

Coolers

While the water cooler in a plant employing mechanical refrigeration is usually a special piece of apparatus belonging to that part of the equipment, it may be of interest to show some of the typical forms used.

A cooler for use with the closed system is illustrated in Fig. 6 and consists of a heavy galvanized iron tank containing an ammonia coil, and the whole thoroughly insulated. The various pipe connections and the method of insulation are clearly indicated in the cut. A rectangular open tank of fairly large size for use with the open system illustrated in Fig. 5 is shown in Fig. 7. Tanks of this kind are usually constructed of wood lined with galvanized iron or copper. They may be insulated by making the walls, top and bottom with a space which may be filled with some suitable material like granulated cork or asbestos sponge.

The double-pipe cooler, shown in Fig. 8, does away with the necessity of a tank and consists of an ammonia expansion coil, inside of which is another coil through which the water to be cooled is passed. In order to prevent heat being drawn from the air through the outer shell of the ammonia coil the cooler should be packed in some good form of insulating material encased in wood or sheet metal.

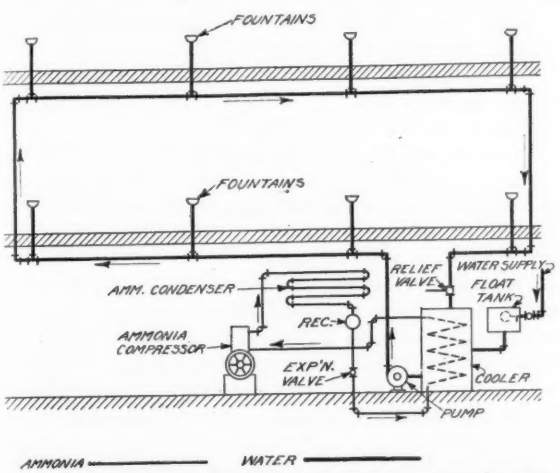


FIG. 5. TYPICAL MECHANICAL WATER COOLING SYSTEM

Computations

Thus far we have only touched upon forms of equipment, systems of piping, etc., without reference to size or capacity. Let us now supplement this by giving some of the data employed in the computations most frequently used in work of this kind, showing its application by a few practical examples.

The first step in a problem of this kind is to determine the approximate quantity to be cooled in a given time. Different authorities give all the way from ½ gal. to 2 gal. per day of 8 hr. per person, depending upon the character of their employment and weather conditions. The lowest figure applies especially to female employes and those engaged in work requiring a moderate amount of physical exertion, as in stores, offices, etc. For the average industrial plant, 1 gal. per day per person should prove ample, while for occupations carried on in high temperatures and requiring great muscular exertion, as in steel works, etc., this may be increased up to 2 gal., according to circumstances. The most healthful temperature for drinking water is from 45 to 50 deg., and systems are commonly designed for delivering the water into the distributing system at 45 deg. or slightly above, and circulating it at such a velocity that it will return to the cooler at a temperature of about 50 deg., thus allowing an average rise of 5 deg.

In a water cooling plant and distributing system the work of refrigeration is made up of four principal parts, as follows: (1)—Cooling the "make-up" water (the quantity drawn from the faucets); (2)—removing the heat absorbed from the air while flowing through the distributing pipes; (3)—removing the heat produced by friction in the pipes; (4)—removing the heat absorbed by the plant equipment, such as cooler, etc.

All parts of the equipment must be proportioned for maximum requirements; that is, the hottest weather and the greatest probable number of people to be supplied. Having estimated the quantity of water to be consumed per hour (make-up water), we must determine the amount of heat to be withdrawn in cooling it to the average temperature at which it is drunk, which may be taken as 47 deg. The average summer temperature of water from city mains is about 60 deg., while that taken from open storage tanks or reservoirs may run up to 70 deg. or more. If we assume the first source of supply, then the make-up water must be cooled through $60 - 47 = 13$ deg., which requires the removal of $8.3 \times 13 = 108$ B.t.u. per gallon.

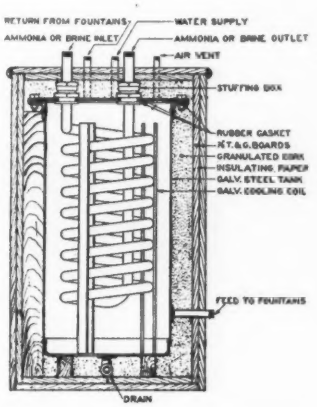


FIG. 6. COOLER FOR CLOSED SYSTEM

The heat absorption from the air during the passage of the water through the distributing and circulating pipes will depend upon the amount of exposed surface, the kind of covering used, and the difference in temperature between the water in the pipes and the surrounding air. Assuming an average water temperature of 47 deg., a maximum air temperature of 97 deg. (a difference of 50 deg.), and the pipes insulated with a good grade of commercial covering, we may assume the following absorption of heat in B.t.u. per hour per *linear* foot of pipe of different size:

TABLE I

Diameter of pipe, in inches.	B.t.u. absorbed per linear foot per hour for covered pipe, with a temperature difference of 50 deg. between the water and surrounding air.
¾	7.5
1	8.0
1¼	9.5
1½	10.5
2	12.0

The heat produced by friction is a variable amount, depending upon the length and size of pipe circuit, number of bends, etc. This may be computed by determining the weight of water to be circulated per hour, and multiplying it by the estimated friction head, in feet, which gives the foot-pounds of work expended. This in turn, divided by 778, will give the heat generated, in B.t.u.

As this computation is somewhat complicated and is only approximate in any case, it seems sufficiently

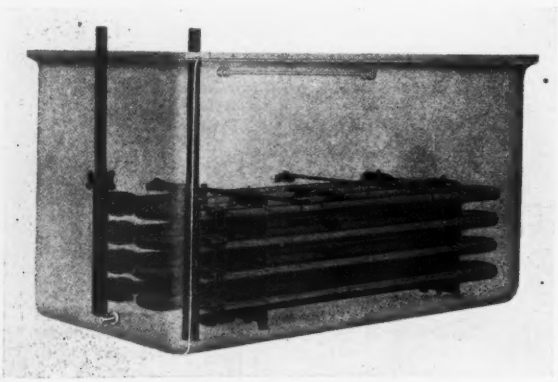


FIG. 7. COOLER FOR OPEN SYSTEM

accurate and more convenient to take this quantity as a percentage of the heat absorption by the circuit as given by the factors in Table I.

Computations made for an extensive system containing approximately 5000 linear feet of piping showed the frictional heat to be about 4 per cent of that absorbed from the surrounding air. Hence, an allowance of 4 to 5 per cent would seem to be ample for this item. The heat absorption of the plant is commonly taken as about 10 per cent of that from all other sources.

With the usual data at hand, it is a simple matter to determine the required capacity of the cooling plant, whether ice or mechanical refrigeration is to be employed. This is best illustrated by a practical example, as follows:

Example—

Persons to be supplied..... 800
Gallons each, per 8-hour day..... 1
Temperature of water supplied from city mains 60 deg.
Average temperature of cooled water..... 47 deg.
Feet of 1 -in. pipe in circuit..... 500
Feet of 1¼-in. pipe in circuit.....1000
Feet of 1½-in. pipe in circuit.....2000

What weight of ice per day of 8 hr. will be required to do the necessary cooling? If mechanical refrigeration is employed, what must be the rated capacity of the plant?

Solution: The first step is to determine the weight of make-up water to be cooled per hour, which is found to be $\frac{800 \times 1}{8} = 100$ gal. or $100 \times 8.3 = 830$ lb. Heat required for cooling this from 60 to 47 deg. $= 830 \times (60 - 47) = 10{,}790$ B.t.u. Next find the heat absorbed from the air during circulation, by the use of Table I, which is as follows:

Heat absorbed in 1 -in. pipe $= 500 \times 8 = 4{,}000$
Heat absorbed in 1¼-in. pipe $= 1000 \times 9.5 = 9{,}500$
Heat absorbed in 1½-in. pipe $= 2000 \times 10.5 = 21{,}000$

Total B.t.u. absorbed per hour by circuit....34,500

Assuming the heat generated by friction to be 5 per cent of the above gives $34{,}500 \times 0.05 = 1725$ B.t.u. for this item.

Heat absorbed by plant, taken as 10 per cent of total heat absorption from other causes, amounts to $(10{,}790 + 34{,}500 + 1725) \times 0.1 = 4702$ B.t.u.

Total heat to be absorbed per hour by the plant $= 10{,}790 + 34{,}500 + 1725 + 4702 = 51{,}717$ B.t.u.

The melting of 1 lb. of ice absorbs very nearly 142 B.t.u.; hence to absorb 51,717 B.t.u. will require the melting of $51{,}717 \div 142 = 364$ lb.

From this we have a total requirement of $364 \times 8 = 2912$ lb., or $\frac{2912}{2000} = 1.5$ tons (in round numbers) per day of 8 hr.

Refrigerating machinery is commonly rated on the tons of ice-melting effect per 24 hr. If 1 lb. of ice in melting absorbs 142 B.t.u., then 1 ton will absorb $142 \times 2000 = 284{,}000$ B.t.u. Hence 1 ton of refrigeration, as the term is commonly employed, is equivalent to the absorption of $284{,}000 \div 24 = 11{,}834$ B.t.u. per hour.

In the foregoing example it was required to remove a total of 51,717 B.t.u. per hour; hence the rating of the machine must be $51{,}717 \div 11{,}834 = 4.3+$ tons of refrigeration, and a 5-ton equipment would probably be installed.

The amount of surface in the coil in the cooling tank will depend upon whether ice or mechanical refrigeration is employed, the initial temperature of the water and amount consumed, the velocity of the water and whether it is circulated through the system or not.

Let us first take the case of cooling by ice. Assuming an initial temperature of 60 deg. for a supply taken from the city mains and a final temperature of 48 deg., the average will be $\frac{60 + 48}{2} = 54$ deg. The temperature of the ice water surrounding the coil will approximate an average between that of melting ice and the water leaving the coil, or $32 + 48 \div 2 = 40$ deg., making a difference of $54 - 40 = 14$ deg. between the average temperature of the water in the coil and that surrounding it. The rate of heat transmission under these conditions depends largely upon the velocity of the water through the coil, and the convection movement

upon the outside due to the slight rise in temperature. Heat transmission from water to water is much more rapid than from water to air, and the usual transmission factor of 2 B.t.u. per square foot of surface per degree difference per hour, assumed for a direct hot-water radiator in still air, must be greatly increased. A series of tests upon two-pipe coolers of the form shown in Fig. 8, with the liquids flowing in opposite directions so as to produce passing velocities averaging 492 ft. per minute, showed an average heat transmission of 112 B.t.u. per square foot of surface per degree of difference per hour. In similar tests with a coil submerged in a tank, in which the combined velocity was reduced to 1.1 ft. per minute, the average transmission factor for the series fell to 36. This latter condition would seem to correspond closely with that of cooling water in a coil submerged in a tank of ice water. Reducing this 15 per cent for the effect of fouling gives a factor of 30, which will be used as a basis in what follows:

Let us take the case of an arrangement like that illustrated in Fig. 2 and assume that 10 gal. of cool water are to be supplied per hour, on an average, from a single unit, what amount of surface will be required in the cooling coil for the temperature conditions previously described? Here we have $10 \times 8.3 = 83$ lb. of water to be cooled $60 - 48 = 12$ deg., requiring the absorption of $83 \times 12 = 996$ B.t.u. In order to cover heat absorption through distributing pipes, cooler, etc., this should be increased about 25 per cent, giving a total of $996 \times 1.25 = 1245$ B.t.u. per hour. The difference in temperature between the water in the coil and that outside was found to be 14 deg., hence the heat transmission per square foot of cooling surface per hour will be $14 \times 30 = 420$, and $1245 \div 420 = 3$ sq. ft. of surface will be required. At this point another factor comes in, that of storage capacity. If the water was constantly moving through the coil at the uniform rate of 10 gal. per hour, a length of pipe sufficient to give 3 sq. ft. of surface would do, but under actual conditions twice the normal quantity of water, or even more, may be consumed in a single hour, hence the length of pipe contained in the coil must be based on storage capacity rather than cooling surface, although it is necessary to check the latter to make sure that it is ample. As a matter of fact the cooling surface will always be much in excess when the following method based on capacity is used:

A safe rule is to make the storage capacity of the coil equal to the quantity of water consumed in one-half hour under normal conditions. Suppose, for example, in the above case the demands are doubled for an hour or so on a hot day, raising the consumption to 20 gal. per hour. If the coil is of 1¼-in. pipe, it must have a length of $5 \div 0.078 = 64$ ft. for a storage capacity of 5 gal., which gives a cooling surface of $64 \times 0.44 = 28$ sq. ft.

Starting with 5 gal. of cold water in the coil, it will all have been drawn out in 15 min. (when normal demands are doubled), at the end of which time fresh water will have taken its place, and have remained in the coil an average of $15 \div 2 = 7\frac{1}{2}$ min. We have found that 3 sq. ft. of coil surface will cool 10 gal. of water in 60 min., or $10 \div 8 = 1.25$ gal. in $60 \div 8 = 7\frac{1}{2}$ min. As the coil actually used is $28 \div 3 = 9.3$ times as large as necessary for normal conditions, theoretically it will cool $1.25 \times 9.3 = 11$ gal. of incoming water while the coil is being emptied of its contents. As only 5 gal. are required to do this, it would seem safe to assume that a coil designed on this basis will prove a continuous cooler for 100 per cent overload. Between these limits the coil may be proportioned for the results it is desired to maintain.

For convenience in making computations of this kind, the following table may be used:

TABLE II

Diameter of pipe in inches.	Square foot of surface per linear foot of length.	Gallons capacity per linear foot of length.
¾	0.27	0.028
1	0.34	0.045
1¼	0.44	0.078
1½	0.50	0.106
2	0.63	0.174

When the water is kept in circulation, the necessary cooling effect becomes greatly increased in proportion to the amount of water consumed, owing to the heat absorbed through the circulating pipes. In this case, however, no account need be taken of the storage capacity of the coil, because the water being in constant motion the whole system of piping acts as storage.

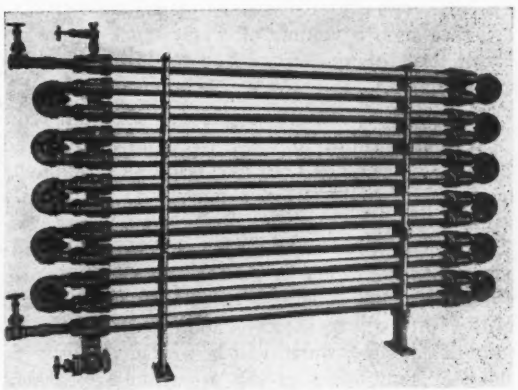


FIG. 8. DOUBLE PIPE WATER COOLER

For greater cooling capacity mechanical refrigeration is usually better because of its greater convenience, and also because of the somewhat smaller cooling surface required. Here, with a suction pressure of 24 lb. per square inch on the compressor, a temperature of approximately 10 deg. can be maintained on the cooling surface, thus giving a greater temperature difference and a correspondingly increased efficiency per square foot of cooling surface under actual working conditions. With ammonia gas inside the coil, the rate of heat transmission per degree difference will not be quite so great as when a liquid is both inside and outside the pipe. A series of tests with ammonia gas in a coil submerged in a tank gave a heat transmission averaging 30 B.t.u. per square foot of surface per degree difference per hour. Other conditions were similar to the tests in which an efficiency of 36 B.t.u. was obtained in case of

the double-pipe cooler. Reducing this about 15 per cent for possible fouling gives a working efficiency of $30 \times 0.85 = 26$ B.t.u. per square foot of surface per degree difference per hour. Assuming an average water temperature of 54 deg. and a coil temperature of 10 deg., we have a coil efficiency of $(54 - 10) \times 26 = 1144$ B.t.u. per square foot, which is equivalent to $11{,}834 \div 1144 = 10.4$ sq. ft. per ton of refrigeration.

Practical Engineer of Jan. 1, 1917, gives 10 sq. ft. of ammonia expansion coil surface per ton of refrigeration for brine cooler service, which corresponds well with the above data taken from another source.

In computing the cooling surface for a system in which the water is in constant circulation, provision must be made for offsetting the heat absorption from the various sources previously mentioned. In the example given earlier in the article, the heat to be removed from the water per hour was found to be 51,717 B.t.u., which would call for $51{,}717 \div 1144 = 45$ sq. ft. of ammonia coil surface.

In computing the volume of water to be circulated and the size of current main, this same quantity of heat comes into the calculations. For example, in the above case, 51,717 B.t.u. are transmitted to the water in the system per hour, and it is desired that its temperature shall not rise more than 5 deg. in making the circuit; hence such a volume of water must be circulated per hour that this quantity of heat added to it will not raise its temperature above a maximum of 5 deg.

One gallon of water weighs 8.3 lb. and requires $8.3 \times 5 = 41.5$ B.t.u. to raise its temperature 5 deg., hence $51{,}717 \div 41.5 = 1246$ gal. must be circulated per hour, or $1246 \div 60 = 21$ per minute to keep the temperature within the required limit.

The size of pipe is usually based on the allowable velocity of flow, which in general should not exceed a maximum of 190 ft. per minute. Even if the water is carefully filtered, a slight amount of sediment will accumulate in time, which will be picked up by a higher velocity of flow, thus giving a turbid appearance to the water. Assuming a velocity of 180 to 190 ft. per minute, different sizes of pipe will carry the following quantities of water without giving too much resistance on the length of circuit given:

TABLE III

Diameter of pipe in inches.	Gallons per minute.	Length of circuit in feet.
1	4.5	1500
1¼	7	2000
1½	12	3000
2	20	4000

In determining the pipe sizes as above it is necessary to make one or more trials, because the amount of exposed surface must be known in order to compute the heat absorption of the line and the volume of water to be circulated to offset this, while at the same time we cannot fix the pipe size until the volume of water is known.

In actual design, the lines of piping are laid out and the size first estimated and the heat absorption computed. From this the volume of water and actual pipe sizes are computed. If these vary materially from those assumed, the surface must be again estimated and the process repeated until the assumed and computed sizes agree within practical limits.

The power for operating a small compression plant such as would be required for a water cooling system will approximate 2 to 3 hp. per ton of refrigerating capacity per 24 hr., which includes pumping the water through the system. Galvanized iron pipe is recommended for the distributing lines, with long sweep fittings to reduce frictional resistance to a minimum. Overhead location is to be preferred, as it provides a more flexible system, and any leaks can readily be detected. The upkeep is also reduced by this arrangement, as the insulation on the pipe is preserved in better condition.

The character of the plant, the grouping of the buildings, location of power house, etc., will exert an important influence upon the arrangement of the pipe line circuits. A supply main with two or more short branch circuits is better than a single one of great length.

While successful installations have been made with circuits up to 5000 ft. in length, it is better to limit them to 1500 or 2000 ft., if possible. One-inch pipe is generally used, but this, of course, depends upon the quantity of water to be supplied on any given line.

THERE HAS never been a time in the history of American shipping when the demand for Merchant crews was so brisk as now, according to a recent report by the United States Shipping Board. The report shows that the board's manning program for 1919 is based on the expectation that 1500 new ships will be ready for manning before the end of the year. It also states that not less than 200 of these ships must be manned before June 1. Of these, 110 are on the Great Lakes, ready to come down to salt water. Crews for these vessels are being forwarded by rail daily from Atlantic ports. Sailors, firemen and stewards are being trained by the Shipping Board, which has hundreds of jobs waiting for young and husky Americans who wish to enter the training service and be in line of promotion for these ratings. Not long ago, the board called for 2000 men to be trained for jobs like these, and it is now ready to take on as many more. Volunteers are wanted from all parts of the country, and they need not have had previous seagoing experience. They will be sent at once to Boston, San Francisco or Seattle for training, will be reimbursed for their fare and will be given training pay for the few weeks they are fitting themselves for the big work of helping man the new ships. When they go to sea they will receive from $55 to $75 a month, according to their rating, also their board and quarters.

INDUSTRIAL AMERICANIZATION is neither complicated nor expensive. It is the interpretation of America to the man on the job, in the natural course of his activities in the plant. Its immediate results will be a good American upon whom the country can rely for all time. Its by-products will undoubtedly be greater efficiency, stability of labor and happier workmen. Both are the responsibility of American industry. The industry of the future which is concerned only with the latter is missing the significance of the passing hour of this war.

F. A. KELLOR.

Automatic Damper Regulator

METHODS OF CORRELATING AIR SUPPLY TO FURNACE AND COAL FED. BY M. E. ALONE

IN the power plant where the load variation on the boiler house is great, considerable trouble is experienced in maintaining constant steam pressure, particularly when the boiler house foreman has no knowledge when the various loads are being dropped. In order to carry a uniform steam pressure, many plants have been forced to install automatic damper regulators. Primarily the object of the damper regulator is to maintain constant steam pressure; but in many plants considerable economy has been gained by their adaptation, particularly so in plants equipped with chain grate stokers.

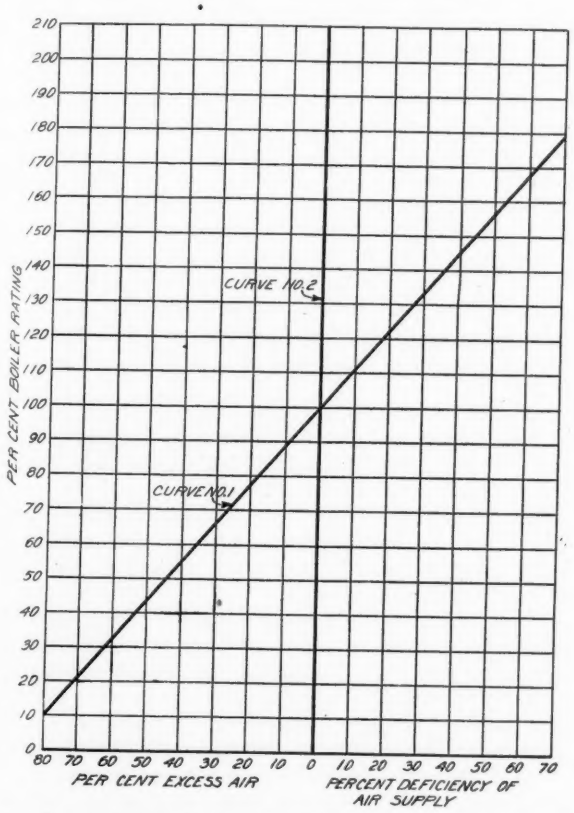


FIG. 1. RESULTS OF TESTS SHOWING RELATION OF AIR SUPPLIED TO BOILER RATINGS

In such plants the stokers are usually driven from a lay shaft, which in turn is driven from a stoker engine. It will readily be seen that for satisfactory results the stoker speed must bear some positive relation to the damper position; otherwise too much or too little air will be supplied for the amount of coal being fed to the boiler, with the result that the fuel bed will either be burned back from the water back, thus allowing excess air above that amount required for perfect combustion of the coal to enter through the bare grates, or the fuel bed will pile up on the water back, allowing unburned coal to pass into the ash pit. Either the piling up of fuel on the water back, or burning short of the fuel bed causes low boiler efficiency. By controlling the position of the fuel bed the automatic damper regulator has perhaps shown better results in economy than any other boiler house equipment.

Designers of damper regulators strive for uniform steam pressure, so that with one or two pounds drop in steam pressure the damper opens up, while with a rise of the same amount the damper starts to close.

Usually damper regulations use water pressure for motive power. The damper and stoker engine throttle valve are connected to cylinders which are fed with water allowed to flow to them from the pilot valves of the damper regulator. The regulator operates a valve which supplies or drains these cylinders with water. As the piston moves in one direction, it either opens or closes the damper and stoker engine throttle valve, thus allowing more or less amounts of coal to be burned.

There are two different types of automatic regulators, one in which the piston takes full travel, thus speeding up the engine to a maximum and opening the damper wide open. The other type assumes different damper positions and stoker speeds for different loads on the boiler.

This latter would seem to be the ideal condition, but in actual operation great difficulty is experienced in co-ordinating the grate speed with damper position, so that the proper ratio of air to coal is supplied.

Figure 1 shows what actually happened in a plant equipped with chain grate stokers and the two types of damper regulator. Curve No. 1 shows air supply plotted against per cent rating of the boiler as obtained with an intermittent position regulator, while curve No. 2 shows the same thing for a full stroke regulator.

Figure 2 shows a diagrammatic sketch of a damper regulator. Usually they are operated from the steam pressure which acts on a diaphragm, which in turn, through a system of levers, operates a pilot valve which admits or drains water from cylinder A, Fig. 2. As the plunger B moves upwards, movement is given to the damper and engine throttle. To correlate these two movements is very difficult.

In the full stroke regulator, the grate speed is set at any desired rate by the governor adjustment with the regulator in wide open position, and the proper position of the damper is determined by viewing the fuel bed and by the aid of flue gas analysis. For the closed position of the regulator, the stoker speed is adjusted by means of a bypass valve in the throttle, the main regulating throttle being closed, so that the proper amount of fuel is fed for the amount of air passing through the grate due to the slight leakage past the dampers when in closed position. The action of this regulator then is such that when the steam pressure is at its high point the stoker is automatically slowed down and the dampers closed. When the pressure drops one or two pounds below the desired high point the stoker is speeded up and the damper opened wide. This leaves only one position at which the air supply and

fuel require to be correlated. It is quite a simple matter to do this.

In the intermittent position regulator if the steam pressure drops below a certain predetermined point the plunger B, Fig. 2, assumes some position, say one-half way open, and this gives us a partially open damper and a certain stoker speed. Now if the pressure still drops the plunger B travels still farther and gives a different damper position and stoker speed. In the same manner we obtain different stoker speeds and damper positions until the plunger B has made its full travel. Thus we have a multitude of positions with this type of regulator at which we have to correlate the air supply and coal feed. It would be possible to do this by running a number of boiler tests having different stoker speeds and adjusting the damper to the proper position for each speed, then making a cam, from the data obtained in these tests, so that the damper would take the proper position for each speed.

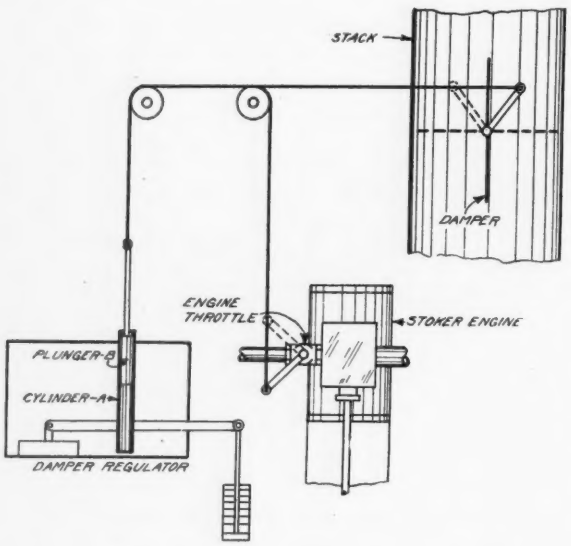


FIG. 2. DIAGRAM OF DAMPER POSITION AND STOKER SPEED REGULATOR

This would be impracticable, due to the fact that each grade of coal would require a new cam, and that the cost of the regulator would be prohibitive. It will readily be seen that when the plunger B is in such a position that the damper is, say, three-quarters open, more opening of the damper will not increase the air supply appreciably, but further opening of the throttle will surely increase the stoker speed such that we have not the proper relation between fuel feed and air supply.

Referring to Fig. 1, the action of the two regulators can readily be studied. The intermittent type for a load variation of, say, 20 per cent above or below normal operation does not interfere appreciably with the condition of the fuel bed and will give practically the same results as the full stroke type of regulator. But if there is considerable variation in the boiler load, then trouble can be expected with the intermittent position type, for there will be an excess of air, as shown by curve 1, for extremely low loads resulting in the fire bed burning short away from the water back, with its consequent bad effects on economy, or with peak loads there will be insufficient air supplied, so that the fuel will pile up on the water back, increasing the ash pit loss by passing over unburned coal and insufficient air properly to burn the remaining coal.

Curve No. 2 shows that as the load decreases the dampers remain closed longer, while with peak loads the damper stays open longer or may go through more cycles; that is, opening and closing oftener in a given time. In either case, with the light or heavy load, whenever the damper is in wide open position—that is, when coal is being burned—we know that we have the proper ratio of air supplied to the coal fed into the boiler.

Some Instances of Retraining

A FORMER bell boy injured at Chateau Thierry, with practically no education and outlook for the future, has been given a short course in an automobile school by the Federal Board for Vocational Education and placed in a large garage, where he is earning a good wage and learning the mechanism of the car, so that his earning capacity will increase.

A young man of ability wounded at Belleau Wood, a member of a family of physicians, who had been trying to earn enough by occupations for which he was untrained, to put himself through medical college, is being given one year of a medical course with the prospect of continuing the training if it proves to be suitable.

Another young man, a physician, lost both his legs in the Argonne and so could not return to general practice. He will be given graduate training so that he may carry on office practice as a specialist.

One young sailor who was prepared to enter medical school lost his hearing from shell concussion, and is being given a course in lip reading to be followed by a course in bacteriology.

One case, typical of many, is that of a young man with general farm experience, who is physically unable to do the heavy work of the farm, because of rheumatism incurred in one of the cantonments, and is being trained in scientific farming, so that he can be placed as a manager with the expectation of ultimately managing a farm of his own. Another who has grown up on a small farm, asked for a course in motor engines and tractor operation, so that he could go into partnership with his father on a large farm suitable for tractor cultivation, as he was incapacitated by an artificial limb for general farm work.

A young Greek, as the result of his service in the army, has a weak heart; having some experience and ability as a salesman, he is receiving a course in a commercial school, with especial emphasis upon English composition, spelling and penmanship.

FROM JAN. 1 of this year to May 7 a total of 204 steamships with an aggregate of 781,980 gross tons were delivered to the United States Shipping Board by American yards. From Jan. 1, 1918, to Dec. 31, 1918, the output was 527 steamships, with an aggregate gross tonnage of 1,991,587. April of this year was the banner month in deliveries, the total being 93 steamships of 320,280 gross tons. The previous best month was October, 1918, when 263,000 gross tons were delivered.

Fuel Burning Equipment of Modern Power Stations

APPLICATIONS OF UNDERFEED STOKERS TO LARGE BOILER UNITS. CLINKER GRINDERS EMPLOYED IN SOME CASES. BY JOSEPH G. WORKER.

WAR necessities brought about, to a certain degree, "conventional" steam power plants. The activities of the different Government administrations, however, exacted requirements in detail conducive to the highest economic operating results. Production, on the one hand, has made the different public service corporations face the necessity of increased power facilities, and the requirements of fuel conservation, on the other, have demanded a careful study of detail problems, not only in the selection of equipment, but in providing means for its economical operation. The co-operative activity of the power plant management, with all these

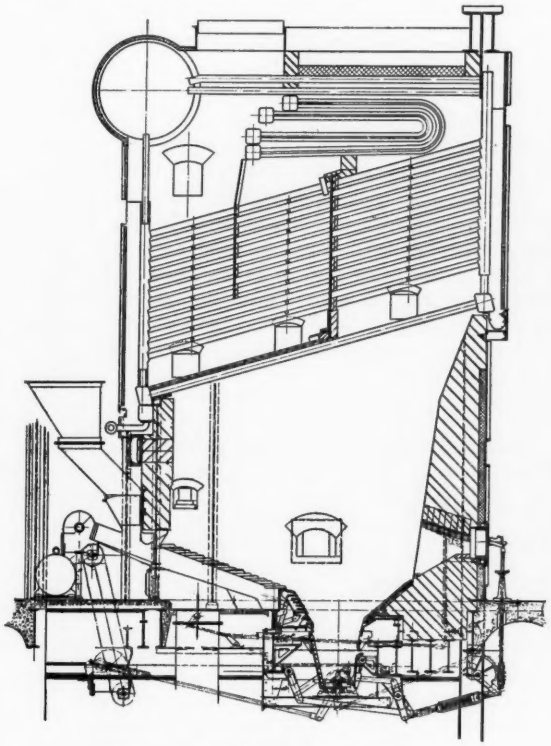


FIG. 1. BOSTON EDISON CO. SETTING

problems, cannot be better exemplified than in the character of the equipment designed for recent installations of new steam plants.

A study of the fuel burning equipment of the most modern plants will show that every consideration is being given to those details which provide for a balancing of the economic results that come from a careful selection of equipment, good supervision and correct operation. It will be found that elaborate means are being provided so that the boiler room organization can do things easily. It is no longer necessary for firemen to climb ladders and crawl over the boiler tops to change the position of dampers, although such methods are still common in many old plants. Mechanisms are being placed at the hands of the operators so that it is not necessary for them to go to inconvenient places in order to control operating conditions.

One of the widely used stokers in the modern stations is the inclined multiple retort underfeed type, designed for large boiler units, ranging from 1200 to 1500 hp. A number of boilers containing 12,600 sq. ft. of heating surface have been used and are furnishing steam for 7000 to 8000 kw. in the prime mover. It is not at all improbable that this unit will be further developed to furnish steam for at least 10,000 kw., in the prime mover for continuous operation. These units are set singly, with large alley ways between settings, so that the boiler and fuel-burning equipment are accessible on all sides. The stokers are designed for a flexible operation of 50 to 300 per cent rating. Clinker grinders are used in a number of cases for discharging the ash and refuse automatically.

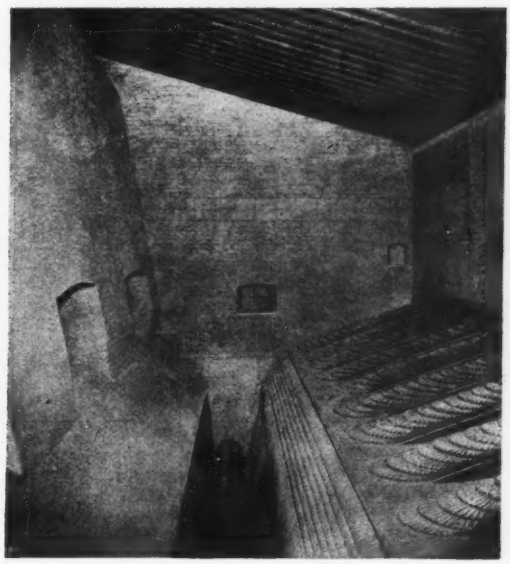


FIG. 2. FURNACE INTERIOR OF BOSTON BOILERS

Brief descriptions of the fuel-burning equipment recently installed in a number of modern power stations cover a wide range in the character of load and fuel used. Some of these plants are completely new stations, while others are extensions to old stations, and still others are old stations in which inadequate fuel-burning equipment has been replaced by more modern equipment.

EDISON ELECTRIC ILLUMINATING CO. OF BOSTON

THIS company has replaced old fuel-burning equipment under eight 512-hp. boilers with inclined underfeed stokers. One of these stokers was equipped with a clinker grinder, the idea being to try this out under regular operating conditions and with the fuel available, this being a part of a study for the new extension to the station. Although the stoker was of small size (five retorts), the clinker grinder operated satisfactorily, and it was decided to use this design in connection with the

equipment for the new extension consisting of four cross-drum boilers, 42 sections wide, 14 tubes high and 18 ft. long, rated at 1232 hp., at 300 lb. gage pressure equipped with a superheater designed to give 150 deg. superheat.

These stokers, as shown in Fig. 1, are of the underfeed type, having 13 retorts installed under the back end of the boiler, under the mud drums, and equipped with rotary clinker grinders, Fig. 2, for removing the ash and clinker continuously. The stoker drives are divided, with not over four retorts to a motor; also the wind boxes and dampers are so arranged that they can be controlled on the same basis, this provision being made so as to give a complete control of coal and air across the entire furnace width.

FIG. 3. REAR VIEW OF BOSTON EDISON BOILERS

The coal usually used is New River of approximately the following analysis:

Fixed carbon	73.50
Volatile	20.75
Ash	5.75
Moisture	3.25
Sulphur	1.05
B.t.u.	14,700

The average per cent of combustible in the ash and refuse is not to exceed 15 per cent. The stoker equipment, when supplied with the above fuel, is designed to develop 300 per cent of normal rating of the boilers for periods of short duration.

Engineers of the Boston Edison Co. worked out a design in which doors are placed in the bridge wall and all controlling mechanism placed at the end opposite the stokers, Fig. 3, so that when the operator views the furnace fires through the bridge wall doors he will have at hand the controlling mechanism.

Buffalo General Electric Co.

For a recent extension of this company's boiler plant, the fuel-burning equipment consists of 24-retort underfeed stokers applied to 1140-hp. cross-drum boilers. Stoker equipment is designed for burning high volatile Pittsburgh coal of about 13,500 B.t.u. as fired, 10 per cent ash, 3 per cent moisture and 2 per cent sulphur. Air admitting dump grates are furnished with the stoker equipment, these being power-operated. To eliminate as much as possible the formation of clinker, air boxes were designed for installation in the side wall.

Combined efficiency for the plant's operating conditions will range from 75 per cent at 200 per cent of boiler rating, to 65 per cent at 500 per cent of boiler rating. The coal burning equipment is designed for continuous capacity of 480 per cent of boiler rating and 600 per cent for short durations. In comparison, this boiler has 24 retorts installed under an 1140-hp. boiler, while at the Delray Station of the Detroit Edison Co. there are 26 retorts installed under a 2365-hp. boiler.

Detroit Edison Co.

At the Delray plant of the Detroit Edison Co. the installation consists of 2365-hp. boilers equipped with 26-retort underfeed stokers, with clinker grinders. Detroit Edison Co. engineers have done considerable work in the development of these clinker grinders. Difficulty was at first experienced on account of the fuel bed breaking, where the fuel left the underfeed part of the stoker, and going into the ash well. It will be noted from Fig. 4 that the grate surface has been curved, this being done in order to eliminate the breaks in the fire. This equipment is run ordinarily at about 150 per cent of boiler rating, but higher capacities can be obtained when necessary. The coal used contains about 13,200 B.t.u. as fired, and 10 per cent ash. Under the above operating conditions the combustible in the ash runs from 14 to 18 per cent.

Minneapolis General Electric Co.

Engineers for H. M. Byllesby Co. have been active in redesigning the fuel-burning equipment of plants

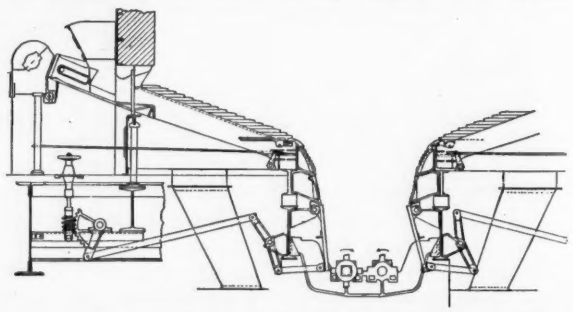


FIG. 4. SECTIONAL VIEW OF STOKERS AT DELRAY STATION

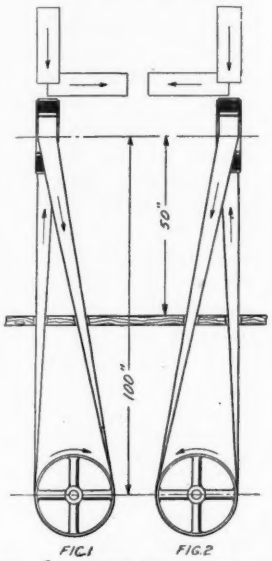
under their management. For example, at the Minneapolis General Electric Co.'s plant underfeed stokers were installed under 12 600-hp. boilers. A recent extension to this plant contemplates the installation of five 14-retort underfeed stokers under five 1300-hp. boilers. On account of the coal conditions prevailing at this plant it was necessary to design equipment for two grades of coal of the following proximate analyses:

	Coal "A"	Coal "B"
Fixed carbon	56.48	43.49
Volatile	30.81	32.59
Ash	11.03	20.44
Moisture	7.00	10.00
Sulphur	1.70	3.48
B.t.u.	13,400 Dry	11,200 Dry

Under the above conditions, the operating performance of fuel "A" ranged from 1800 to 3000 hp. continuous and 4500 hp. for short durations. With the poorer grade of coal, the maximum capacity was reduced to 3000 hp. for short durations.

Setting Out Belt Clearances for Oblique Drives

WHEN the alinement of the pulleys for a half-twist belt drive is under consideration, as illustrated as an example in Fig. 1 (which shows the pulley on the lower floor being driven clockwise, the pulley on the upper floor being driven at right angles to the driver), the rule for alinement is as follows: A center line taken from the face of the driving pulley at a point level with the center of the shaft, and on the side where the belt leaves the pulley, as shown in Fig. 1, must be in



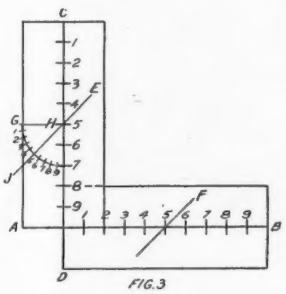


FIG. 1. HALF-TWIST BELT DRIVE WITH DRIVER RUNNING CLOCKWISE

FIG. 2. HALF-TWIST BELT DRIVE WITH ROTATION OF DRIVER OPPOSITE TO THAT IN FIG. 1

FIG. 3. METHOD OF SETTING OUT TWISTED BELT DRIVE

the same line vertically as the corresponding point on the driven pulley; this position also being indicated in the plan view of the two pulleys.

Always it must be remembered that the direction in which the driving pulley rotates will determine which of the two sides of the driven pulley must be set in line with the driver, as it is always the side from which the belt leaves the pulley which should be worked from.

Figure 2 illustrates the reverse of this method—that is to say, when the driven pulley, which in this instance is also the lower one, rotates counter-clockwise.

Now let us assume an example of drive as in Fig. 1 to be set out, starting with only the lower pulley on the driving shaft; the problem presented us being to locate the position of the upper pulley and also to arrange for belt clearance on the floor. We should first start by dropping a plumb line down from the underside of the flooring in order to ascertain the center of the face of the pulley on its proper side relative to its direction of rotation; then through the flooring pierce a small hole to give us a starting point for our clearance diagram. Next we should set out on the upper floor a line A B as in Fig. 3, in exact agreement with the line shaft, then put in full size the outlines of the pulley, as shown. From the face of this pulley set out a square line C D, then from the line A B as a starting point set out full the diameter and width of the pulley proposed to be driven.

Now divide each pulley diameter into any equal number of parts, in our example this being 10, and number them in the order indicated, No. 1 starting in each case from the side of the pulleys opposite the arrow points as in the plan view Fig. 1. The next thing in order is to find the total length between the shaft centers, also the distance from floor level to the center of the upper shaft, in our example this being 100 in. and 50 in. respectively. As $100 \div 10 = 10$, each division on the pulley will be equivalent to 10 in., and $50 \div 10 = 5$, which represents the number of spaces that the center of the belt will be from the center points of the sides of the pulley, as indicated at E in the diagram. Now draw the line G H, square with the center line C D, through the point thus found in the outline of the pulley whose center is A B; then with H as center and G H as radius describe the arc shown, dividing this also into 10 equal parts.

Start numbering these divisions from the point G, then set off 5 spaces from G, thus determining point J, and draw the line E J through H; H E and H J being of equal length, and representing the width of the belt. This line indicates the position of the belt at the floor line, and a line set out at F parallel to it and cutting the same division gives the other center line of the belt.

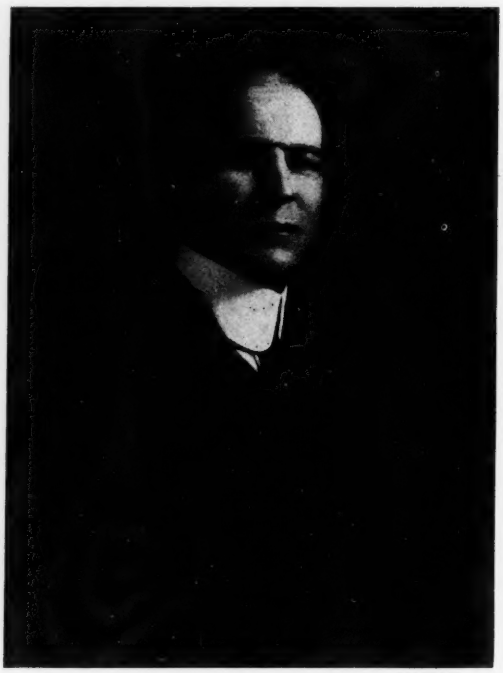
The necessary clearance to permit the belt to pass through the floor, sufficient to prevent rubbing, and to clear whatever form of fasteners are used, can now be definitely decided upon.—Mechanical World.

DURING the progress of the war army statistics indicated the interest taken in the educational courses by tuberculous soldiers. These constituted by far the largest number of those enrolled for courses in army hospitals. The records of the Federal Board for Vocational Education continue to show this same interest in the discharged soldier suffering with tuberculosis. Recently three men, discharged from the service with this disease, came to the Federal Board for training—their compensation having been established by the Bureau of War Risk Insurance. Possessing a college education in addition to practical experience, they were able to take short, intensive courses, preparing themselves for instructors in light arts and crafts. As special advisers and instructors, they have been sent to widely separated fields; one has gone to a sanatorium in North Carolina, another to Massachusetts and the third to Texas. They carry with them to these far distant corners of our land the encouragement that must come to the tuberculous in these hospitals from contact with men, who, having overcome handicaps similar to their own, are now leading lives of usefulness.

DAVID MOFFAT MYERS

ORGANIZED AND DIRECTED NATION-WIDE FUEL CONSERVATION PROGRAM.
THE HERBERT HOOVER OF THE COAL PILE. BY OSBORNE MONNETT

NOTHING has so aroused the power plant interests to a sense of their possibilities and responsibilities as the activities of the U. S. Fuel Administration with respect to its rulings on conservation of coal. Evidence that the good accomplished is not lost can be found on every hand. More interest is being taken in those fundamental questions of power plant operation, formerly looked upon as too theoretical for the practical man and altogether out of reach of the business man. The power plant, which heretofore has involved the largest element of uncertainty, is to be put on a business basis and kept there.



Use of questionnaire, establishment of State Administrative offices, and other great measures were involved in this work, which saved 25 millions of tons of coal per year in the industries and railroads at a time when coal was so badly needed, and which, owing to its educational value, will be responsible for future savings difficult indeed to estimate.

To David Moffat Myers, who has recently completed his work as Advisory Engineer to the U. S. Fuel Administration as a dollar a year man, and who is returning to private practice in New York, must be given the credit for conceiving and putting into effect the technical details of this great conservation work. While his practice in the general power plant field has been extensive, he will perhaps be more widely known and better remembered by the engineering public for the impetus he has been able to impart to the question of power plant economics, the far-reaching effects of which will be felt in engineering circles for many years to come.

Being associated in the past with the stoppage of waste in industrial power plants, re-claiming of waste fuels and other measures having a bearing on economical power generation, he had made an exhaustive study of the factors entering into the situation and was in an exceptional position to appreciate the vast possibilities of proper corrective measures, if applied on a wholesale scale to the country at large.

Struck with the immensity of the field and the necessity for some work of this kind, Mr. Myers in 1917 went to Washington, laid the matter before Fuel Administrator Garfield and was invited into the organization to work out a power plant conservation plan on a national basis. An outline of the program was subsequently presented before the A.S.M.E. in December of the same year, in a paper entitled "Preventable Waste of Coal in the United States."

His work involved building up a large organization in Washington and in the States, which had enrolled 1500 volunteer engineers in addition to the numerous other members of committees and workers. Included in the program were many features on classification and rating of power plants, based on the thoroughness with which they were found to be carrying out the specified recommendations. For the administration of this work a Fuel Engineering section in the Conservation Bureau was organized, of which Mr. Myers was the head.

He was also appointed member of the committee of consulting engineers to the Bureau of Mines, an advisory body on fuel conservation, and as a member of the A.S.M.E. sub-committee on coal, his duties were similar.

Mr. Myers is only forty. He was born and raised in New York State, educated in its public and private schools and was graduated from Columbia University in 1901, receiving the degree of M.E. Early he became convinced that there was a demand in the industrial field for unbiased technical advice in connection with steam generation. He has steadfastly adhered to the professional rather than the commercial ideals of an engineer and has established an enviable reputation.

During the first five years of Mr. Myers' professional

experience, he served as mechanical engineer for U. S. Leather Co., in charge of testing, investigating and reporting on the steam and fuel conditions of about 100 plants of this company. His duties also included the remodeling of old plants and the designing of new plants for production of steam and fuel economies. This involved a large amount of engineering research work on waste fuels and original design of furnaces for burning them.

In connection with this work he designed furnaces which successfully burned waste spent, and chestnut chips, which contain about 65 per cent moisture and had hitherto resisted all attempts to burn without a heavy mixture of coal or auxiliary fuel. These furnaces not only burned this fuel, but did so at a high degree of efficiency, developing overloads on the boilers and making large savings in plants where they were installed. He has since done a large amount of original furnace designing for special waste fuels and has many of these furnaces working in different parts of this country and in Cuba.

In 1906, against the advice of friends and advisors, he opened his own offices as consulting engineer, specializing on the economy of steam and fuel in industrial plants, and is at present continuing this practice.

Four years ago he became associated in partnership with John S. Griggs, Jr., and has been active in making investigations and reports on steam and fuel conditions in industrial plants; and in preparing plans and specifications covering complete improvements or new developments, supervising work of installation, testing the completed plant, and installing a proper management system.

Mr. Myers has written two books on power plant management and design, one entitled "Preventable Losses in Factory Power Plants"; and the second, recently published, is "The Power Plant."

An engineer by profession, a sailor by instinct, he has always taken a keen interest in marine matters and has now under way an important movement looking to amelioration of conditions in the fire room of our Merchant Marine, where labor saving devices are as yet virtually unknown, but where, owing to the size and horsepower involved, conditions should be comparable with similar sized power plants in the stationary field.

As might be supposed, his recreation is yachting. As soon as the ice and winter winds have disappeared he can be found at week-ends, afloat on the Sound. He is at his best when the smell of salt water is in the air and many important engineering problems have yielded their solution amid such surroundings when inspiration came slowly in the ordinary environments ashore. He is a member of the famous Bayside (L. I.) Yacht Club, a larger percentage of whose membership was represented in active Naval and Military War work than in any other similar organization in the country.

Mr. Myers undertook a gigantic, complex task, the successful execution of which reflected the possibilities of the engineer in public life.

TO SUCCEED get ahold, and hang on—inertia is often as good as enterprise, but both are necessary to all around development leading to a worthy goal.

A Voice From the Stokehold

STOKERS with diplomas from colleges, who carry a pocket volume of the classics about with them to fill in their leisure hours, have been reported among the American boys who are now entering the Merchant Marine in large numbers.

Accounts of these learned firemen from time to time have reached the Shipping Board, but only recently has concrete evidence of the presence in the merchant service of firemen who can write schoolmaster's English that might have been learned through reading the old essayists come to hand.

Such evidence came in the form of a letter from Victor F. Stern, an apprentice fireman on the Shipping Board training ship Minnesota, at Norfolk. The letter gives the writer's reasons for thinking well of the Merchant Marine. In a footnote he states that he was engaged as a newspaper reporter prior to entering the Merchant Marine. His letter follows:

"To one tied to an office desk 300 days in the year, the chance to break loose comes as a heavenly boon carrying rewards beyond first expectations. While there is selfishness in seeking attachment to such a service as the Merchant Marine, there is an element of duty as paramount as that of loyalty to country. That duty redounds to my own physical, mental and moral well-being, for, without the needed exercise, vitalizing air and change in mode of living, I may little hope to return to an exacting civil life, if ever that wish should seize me.

"Now that I am completing my apprenticeship as a marine fireman, awaiting the call to be shipped on transport or freighter, I can say I have struck the quieting chord of encouragement and hope. I knew entrance into marine life called for sacrifices and at the outset these were hard to make. But I soon learned to gain the right focus. The nervous strain of city life, the countless unprofitable excursions of burdensome account to persons and places, accomplished by the din of subway screechings and factory irritations are behind me.

"I chose the job of fireman, first, because it is muscle building. In 5 wk. I gained more hardiness than I had gained in 6 mo. gymnastic exercise. When you're earning your physical development at a job, the advance made is natural. Voluntary exercising, as a pastime, is not fully productive.

"And what a pleasure to link the furnace with myself. My schoolboy learning was returning in practical application. I began to look upon the outer shell of a boiler as I would the skin. Then there are the tubes corresponding to the blood cells, the combustion chamber to the stomach, the fire-door to the mouth.

"I am proud to be a fireman, although there must be just as interesting studies in the deck or steward's department. Once you strike such a chord in your work, the earlier hardships and monotony fast disappear.

"Thus, into an entirely new world, still full of those adventurous possibilities dreamed by youth, the recruit, with eyes and ears close to the waves, mind and heart wrapped in the glory of his job, is bound to conclude Uncle Sam has offered him the opportunity of a lifetime in taking him into the Merchant Marine."

Superheated Steam

Why It Is, What It Is and Its Advantages

STEAM ordinarily furnished by boilers is termed "saturated" because, even if dry, it is in such condition that any loss of heat results in part of it reverting to water or condensing.

Loss by radiation in the pipe lines and in the engine cylinder therefore condenses some of the steam, and this water of condensation added to the water entrained or carried out of the boiler (by the steam) forms a useless and detrimental factor. Heat being the source of power, its loss means loss of power, and especially when it results in forming water which can give no power and which is cumulative in its effect of hastening the condensation of more steam.

"Superheated" steam has no water, and it must lose all its superheat before it begins to condense. It is a perfect gas and is really in the condition steam should be in for efficiently accomplishing its purpose. When saturated steam enters the superheater the latter must convert such water as it contains into steam and then superheat the whole mass. The oft-repeated cry of "wet steam" and the troubles caused thereby, are eliminated if steam is superheated to meet the conditions.

The fact that steam to be right and in proper condition, must be superheated and the further fact that when it is superheated it will accomplish its purpose so much more satisfactorily and economically than will saturated steam, makes it appear that the millions of horsepower which have been developed with saturated steam have been made with great waste. Now that superheated steam may be readily obtained and efficiently used, this waste becomes almost criminal and the conservation of fuel dictates that superheat be adopted extensively and quickly as possible. There are other means of obtaining economy in the use of fuel but none of them are more reliable and as sure and satisfactory as is superheating the steam.

The proper and economical use of high pressure in the engine presented new problems. To expand steam of high pressure and temperature to atmospheric pressure and its corresponding low temperature meant a great range of temperature in the cylinder and much of the incoming steam was condensed. By using two or more cylinders the drop in temperature was lessened in each with consequent reduction in condensation, so the compound, triple and quadruple expansion engines were developed.

By condensing the steam used in an engine, a vacuum was obtained which reduced the back pressure of the atmosphere and added by so many pounds the effective pressure in the cylinder. As a vacuum increased the range in pressure and temperature the multiple cylinder could take advantage of this with economy and condensing apparatus was much used, reaching a high state of development.

The engine itself, with its valves, valve gear and governor, was so improved that it could economically take advantage of high pressure mainly because of automatically cutting off the steam to suit the load. All parts and materials entering into engine construction were bettered to meet conditions, and thus we had an easy and natural development along lines which did not include the use of superheat.

Now came a steam using unit, the turbine, which was able to use economically steam through a great range of pressure and temperature, so that even higher pressures and greater vacuums were brought into service, to the end that new economies in the consumption of steam were established.

The water in wet steam wears the blades of a turbine and superheated steam is almost required to operate it in order to lessen this wear. Turbine builders also guarantee a specific saving in steam consumption for a given superheat, which makes it doubly serviceable in a turbine plant.

Another development in prime movers using steam is the poppet valve engine and its corollary, the uniflow engine. Good economies are obtained with these engines, and here again the manufacturers will guarantee additional economy when using superheated steam, the valves of the engines making them peculiarly adapted to its use.

Thus we see that the ease of getting higher pressure steam made it natural that it would be used, especially if the means were provided for getting and using it. All the factors entering into a power plant being constantly improved on these lines, they became the lines of least resistance, and thus we have our present practice. However, the development along said lines has reached the point where little further improvement can be expected, and therefore the saving due to superheat is being considered.

"Superheat" is the amount of heat, as indicated on a thermometer, over and above that which steam would have at a given pressure. From tables showing the properties of saturated steam we find that steam at 100 lb. pressure has a temperature of 338 deg. F. If the superheater gives it a final temperature of 438 deg. it would have 100 deg. of superheat, and with a final temperature of 488 deg. the superheat would be 150 deg. F. Besides its characteristic of not condensing until all its additional heat units are lost, superheated steam has additional expansive or power producing effect due to its extra heat, and consequently the cutoff will be earlier in an engine for a given amount of power developed.

The apparatus for obtaining superheat is called a superheater, and contrary to a popular belief, it can seldom be placed in the path of the waste heat of the boiler. The steam should pass through a superheater at a speed of approximately 4000 ft. per minute to obtain the best results, which means it takes but a short time to pass through the apparatus. This fact and the low conductivity of the steam requires a big difference between the temperature of the gases and that of the steam, hence the superheater must be placed where hot gases circulate about it freely. So placed, it takes heat from live gases, which means fuel used to get superheat, but so much less steam is generated that there is a large net saving in fuel.

Nor can steam be successfully superheated in any old collection of pipes. Due to its low conductivity, it must be divided into small quantities or else filmed (or sheeted) in its passage through the superheater. The former method contemplates a number of smaller pipes, and the latter is done by having pipes within pipes, the steam passing through the annular space thus formed. In both designs the pipes or, as we shall call them, the tubes, are secured into headers which distribute the steam among the tubes. There is a third method, rapidly coming into vogue, whereby with two pipes, one within the other, steam enters through the inner pipe, which is perforated and then jets out of these perforations into the annular space, thereby agitating the steam and efficiently superheating it.

The materials of a superheater are prescribed by the boiler codes and are inspected by the boiler insurance companies, because of their having to insure them as a part of the boiler. The design of such apparatus, however, is varied and is the subject of great consideration. The headers must be of steel, properly shaped and proportioned to give good distribution of steam to the tubes. If they are placed outside of the boiler setting, so much better for accessibility of inspection and repairs. Repairs and upkeep of a superheater should be a minimum, but when the repairs are necessary, facility for making them is desirable.

Due to the absence of moisture, superheated steam has less friction passing through pipes than has saturated steam, the speed of travel can and should be higher and the piping, fittings and valves smaller. When piping is designed especially for superheated steam the reduction in size will go far towards paying for the superheaters. Where it is turned into an existing system of piping, the radiation may be somewhat greater than if the piping was of proper size, but the reduction pressure would be less. The actual radiation from superheated steam, under similar conditions, is less than it is with saturated steam because, even though the temperature is higher, its low conductivity makes it lose heat less rapidly. Besides, the pipes are not so wet, and hence have less conductivity. Depending on the steam speed and the pipe protection, superheated steam is figured to lose one degree of superheat in from 6 to 10 ft. of travel. Where long pipe lines are used the results of using superheat are little short of marvelous, and anyone having such lines is working against his interest by not investigating what it may do for him.

The exhaust from an engine using superheated steam contains practically as many heat units as the exhaust from an engine using saturated steam. It contains less moisture and is therefore in better condition to perform any service to which exhaust may be put.

The exhaust from any steam using machine, such as engine pump or turbine, may itself be superheated and thus be made the medium of conducting more heat or of increasing the temperature for special purposes.

A constantly increasing number of plants are being equipped with superheaters. What is coming into the limelight at present is not the value of superheat, which is established, but its value in the medium sized plant and the fact that a moderate degree of superheat, heat that gives a temperature, can be given to the steam in most existing plants without disturbing them.

The steam consumption in an average plant of medium size is from 30 to 40 lb. of steam (water) per horsepower per hour, and in such a plant superheated steam should save from 15 to 25 per cent, the fuel saving from 10 to 20 per cent. There are specific instances of a water works saving 30 per cent of its fuel, ice plants 25 per cent, locomotives 18 per cent, all in a year's test, and numerous instances where the saving is from 16 to 20 per cent. So many factors enter into the operation of a plant that the range in saving is great, and it is likewise difficult for the manufacturers of superheaters to make any definite guarantees on the matter. Loads vary, coals vary, the firing varies and there are other varying factors, but the one long chance is, that by putting in superheat the man paying for fuel will find a great reduction in his bills, thereby paying handsome returns on the superheater investment.

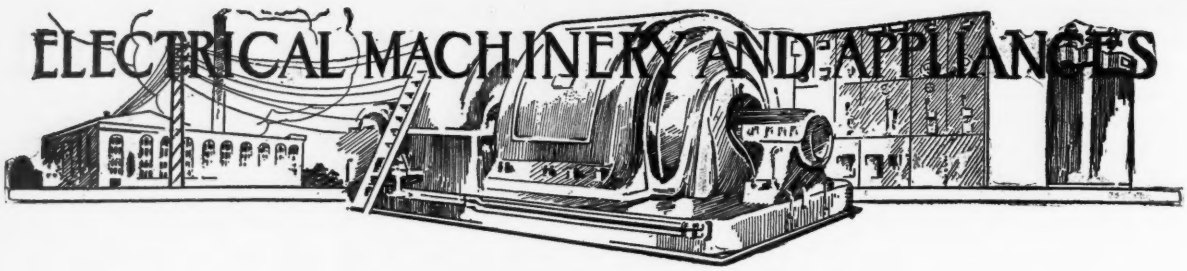
Such savings of steam as have been enumerated mean greater capacity in an existing boiler plant; if a new plant is being installed, a lesser boiler capacity can be figured, thereby saving all that the superheating apparatus may cost, not to mention the saving in piping to which reference has been made.

There are many auxiliaries in a steam plant which make for saving fuel, such as feed-water heaters and regulators, damper regulators, CO_2 recorders, mechanical stokers, economizers, condensers, etc. Superheat conflicts with none of them and will still save even if all are installed. It is, with proper apparatus, the one reliable, sure and safe means of getting economy.

We have read why improper oils, packings, valves, undeveloped engines and unsuitable apparatus for obtaining superheat, all caused it to be passed over in the earlier days of the steam plant, but now that all these elements have been brought to a suitable state of superheat, there is no longer reason for any plant refusing to consider its benefits. Competition is going to be keen and will call for every resource of a resourceful people, while the conservation of fuel is a vital consideration which self-interest and patriotism alike dictate as good policy. Superheating is one of the easiest, best and altogether satisfactory ways of getting in line to meet competitions and conserving fuel.

THE TRAINING of disabled soldiers, sailors and marines is now given in the best institutions of the United States ranging from Harvard and Yale, Massachusetts Institute of Technology, Case School of Applied Science, Columbia University, and the various land grant colleges of the state to agricultural schools, scientific schools, and in some instances direct in the industries. There are, altogether, some 500 trades, professions, occupations, callings, and the industries from which a choice may be made by the disabled man. He is, by no means, confined to manual trades and occupations, and the sole animating and dominating thought and object of the government, as expressed and carried out by its agent, the federal board for vocational education, is to do that thing for the disabled man which will insure to him the greatest possibility for future usefulness, happiness, and contentment according to his capabilities.

YOU CAN LEAD a boy to college, but you cannot make him think.



A Study of Dynamo Electric Machinery---III

CALCULATION OF MAGNETIC CIRCUITS AND MAGNET WINDINGS. BY OTTOMAR H. HENSCHEL

SHOWN in Fig. 12 is a table of the magnetic properties of iron and steel. Knowing the value of B, the required or desired flux density in lines per square inch, it is readily possible to learn the corresponding value of H or magnetomotive force in turns per inch length.

Assuming the magnetic circuit under consideration to be made of cast steel and to have a required flux density of 40,000 lines per square inch of section, we find the corresponding number of ampere-turns required to be 13.40. In a like manner the value of H or ampere-turns per inch length of circuit for cast iron with a flux density of 60,000 lines per square inch is 224.00.

Permeability represented by u is, as learned in the preceding article, equal to B divided by H or the flux density in lines per square inch divided by the number of ampere turns per inch length, so that H is equal to B divided by u. Referring to the table of the magnetic properties of iron and steel, Fig. 12, we find that for carbon sheet steel the value of H corresponding to 50,000 is 13.20, while that of u is 3796.0, the quotient obtained by dividing 50,000 by 13.20.

In calculating the number of ampere-turns required for a given generator or motor field winding account must be taken not only of the metallic section of the magnetic circuit, but also of the air gaps existing between the face of the pole pieces and that of the armature. This may be determined in the same manner as that employed for the other portion of the magnetic circuit except that for u a value of 3.19 must be employed, 3.19 being the number of perms permeability per inch cube of air.

Where the value of B is equal to 30,000, the required number of ampere-turns per inch length is equal to 30,000 divided by 3.19, or 9404. Similarly with a flux density of 90,000 lines per square inch H has a value of 28,214.

The values of relative permeability as given in the table, Fig. 12, are, it will be seen, equal in each case to the value of u or absolute permeability divided by 3.19.

FIG. 12. MAGNETIC PROPERTIES OF IRON AND STEEL

Carbon sheet steel (annealed)				Cast steel				Mild steel forgings (wrought iron)				Cast iron			
B	H	u	u_p	B	H	u	u_p	B	H	u	u_p	B	H	u	u_p
10,000	5.01	1,996.0	625	10,000	5.64	1,774.0	556.0	10,000	3.76	2,667.0	833	10,000	20.00	497.5	156.0
20,000	7.20	2,775.0	870	20,000	8.77	2,278.0	714.0	20,000	4.70	4,252.0	1,333	20,000	32.90	609.3	191.0
30,000	8.77	3,416.0	1,071	30,000	10.90	2,791.0	875.0	30,000	5.64	5,091.0	1,596	30,000	51.40	583.4	183.0
40,000	10.30	3,866.0	1,212	40,000	13.40	2,967.0	930.0	40,000	7.20	5,547.0	1,739	40,000	82.10	488.1	153.0
50,000	13.20	3,796.0	1,190	50,000	16.90	2,954.0	926.0	50,000	9.40	5,318.0	1,667	50,000	134.00	370.0	116.0
60,000	16.80	3,611.0	1,132	60,000	22.50	2,657.0	833.0	60,000	13.90	4,351.0	1,364	60,000	224.00	265.7	83.6
65,000	19.00	3,420.0	.....	65,000	25.00	2,500.0	797.0	65,000	16.00	4,070.0	1,276	65,000	322.00	201.3	63.1
70,000	21.30	3,285.0	1,029	70,000	31.00	2,255.0	707.0	70,000	20.40	3,436.0	1,077				
80,000	29.40	2,715.0	851	80,000	45.70	1,745.0	547.0	80,000	32.60	2,453.0	769				
90,000	43.80	2,060.0	652	90,000	70.50	1,276.0	400.0	90,000	62.60	1,436.0	450				
100,000	67.00	1,490.0	467	100,000	117.40	851.7	267.0	100,000	134.70	743.2	233				
110,000	117.00	937.9	294	110,000	228.60	481.7	151.0	105,000	197.20	532.7	167				
120,000	227.00	526.4	165	115,000	317.90	360.5	113.0	110,000	324.20	338.1	106				
125,000	365.00	370.0	116												

B Flux density in lines per square inch.
H Ampere-turns per inch length.
u Absolute permeability, perms per inch cube.
u_p Relative permeability as compared with that of air.

CALCULATION OF THE MAGNETIC CIRCUIT

THE ELECTROMOTIVE FORCE induced within the armature windings of a generator is, as explained in the first article of this series, directly proportional to the total flux, the value of which is in turn dependent upon the magnetic intensity or number of ampere-turns. Knowing the flux required, the total number of ampere-turns may be determined by calculating the number of ampere-turns necessary to produce this flux in each component part of the magnetic circuit and taking the sum of such numbers of ampere-turns.

In a simple bi-polar machine, the magnetic circuit may, as indicated in Fig. 13, be made up of an arma-

ture of carbon steel laminations, two air gaps, two cast-iron pole pieces, two cast-iron cores and a yoke of wrought-iron here employed as a base for the machine.

Let us assume a maximum flux of 1,000,000 lines required, and that the base piece has a sectional area of 15 sq. in., each of the cores 20 sq. in., each of the pole pieces a minimum section of 25 sq. in. and the armature 48 sq. in. The armature has a diameter of 8 in. or a circumference of 25.12 in., so that with each pole piece width of 6 in., each air gap (neglecting leakage) has a sectional area of 1/3 (under the assumption that each pole piece face covers 1/3 of the armature surface) times 25.12 times 6, or 50.22 sq. in.

As the total flux required is 1,000,000 lines of force, and as the wrought-iron base piece has a sectional area of 15 sq. in., the flux density in this element is equal to 1,000,000 divided by 15, or 66,660 lines, or for all practical purposes let us say 65,000 lines. Referring to the table, Fig. 12, we find that where a flux density of 65,000 lines is to be maintained in a magnetic circuit of wrought iron, the required value of H or the number of ampere-turns per inch length is 16.00. The length of this part of the circuit is 12 in., and as a consequence a total of 12 times 16.00 or 192 ampere-turns are necessary for the production of 1,000,000 lines.

Each of the cores has a sectional area of 20 sq. in. and a flux density of 1,000,000 divided by 20 or 50,000 lines, thus requiring, as shown under Cast Iron of the table, Fig. 12, a value of 134.00 ampere-turns per inch length. Multiplying this by 12 (the total length of the two cores) we obtain 1608 as the necessary number of ampere-turns for this part of the machine. With a sectional area of 25 sq. in. for each of the pole pieces, the required number of ampere-turns is 985.20.

The armature, which is made up of carbon sheet steel, has a maximum sectional area of 48 sq. in. and a length of, let us say, of 8 in. The flux density through this member of the machine is then 1,000,000, divided by 48, or 20,835 lines per square inch. Accepting 20,000 lines, we find the corresponding value of H for carbon sheet steel to be 7.20, which times 8 is equal to 57.60 ampere-turns.

Due to the reluctance of the path of air between the face of the pole pieces and the surface of the armature, a correction or leakage factor must be employed; that is, the total number of lines of flux required, or 1,000,000, in this particular case must be multiplied by a factor which in practice varies from 1.1 to 2.0, to determine the actual number of lines of force to be developed. Let us assume this factor, known as the leakage factor, to have a value of 1.3. Multiplying 1,000,000 by this, we obtain 1,300,000, the number of lines of force upon which the required number of ampere-turns must be based.

The armature has a circumference of 25.12 in., one-third of which, the portion covered by the face of each pole piece, is 8.37 in. This times 6 is 50.22 sq. in., the area of the section of the air path. Dividing 1,300,000 by 50.24, we obtain 25,875 lines as the flux density of each air gap.

The permeability of air is 3.19 perms for inch cubes, so that the required number of ampere-turns per inch path is equal to 25,875, divided by 3.19, or 8111. The length of the two air gaps is, however, but 0.25 in., and as a consequence the actual number of ampere-turns required is 8111 times 0.25, or 202.77.

We then have for

Yoke or base piece	192	ampere-turns
Cores	1608	ampere-turns
Pole pieces	985.20	ampere-turns
Armature	57.60	ampere-turns
Air Gaps	202.77	ampere-turns
Total	3045.57	ampere-turns

Calculating Resistance of Conductors

The resistance of any electrical conductor varies according to the material of which it is composed, its length and its cross-sectional area. As the resistivity of the conductor—that is, its specific resistance or the resistance of a wire of unit length and of unit sectional area decreases as its length decreases and as its cross-sectional area increases—so will its resistance decrease. On the other hand, with an increase of resistivity, an increase of length and a decrease of cross-sectional area, the resistance will increase. This may be expressed numerically by the following formula:

$$R = p\,l \div a$$

where R is the resistance in ohms, p the specific resistance, which for commercial copper wire may be taken as 10.8 (the resistance of a wire 1 mil in diameter and 1 ft. long) the cross-sectional area of the wire in circular mils and l the length in feet.

Let us assume that the field coil of an electric generator is wound with 1000 ft. of No. 14 gage, B. & S. (the sectional area of which is 4110 cir. mils), copper wire, and that it is desired to determine the resistance of this winding at ordinary room temperature.

Applying the above formula we have,

$$R = p\,l \div a = 10.8 \times 1000 \div 4110 = 2.36 \text{ ohms.}$$

Another factor, however, requiring consideration in calculating the resistance of any conductor is its temperature, for as the temperature increases the resistance increases, the rate of such increase depending upon the temperature coefficient of resistance of the given material. This coefficient, which in reality is the number of ohms increase in resistance per degree rise in temperature, is, when based upon the Fahrenheit scale, equal to 0.0023 for high-grade commercial copper.

The total resistance R_t of any conductor at a temperature t deg. F. above initial temperature may then be determined by adding to the resistance in ohms at initial temperature, the product of the resistance in ohms at initial temperature, the temperature coefficient of resistance and the number of degrees rise in temperature, or

$$R_t = Ro + RoKt$$
$$= Ro\,(1 + Kt)$$

where Ro is the resistance of the conductor at initial temperature, K, the temperature coefficient of resistance and t the degrees Fahrenheit rise in temperature.

Where calculations are based on degrees Centigrade, the temperature coefficient of resistance is 0.00402.

If the winding of the coil referred to above has a resistance of 2.36 ohms at a temperature of 50 deg. F., its resistance at 120 deg. F. is equal to $2.36\,(1 + 0.0023 \times 70)$, or 2.73 ohms.

Coil Windings

Knowing the number of ampere turns necessary to establish and maintain the required magnetic flux, the problem to be solved is the determination of the size of wire to use which, under the working voltage, will, with the proper number of turns, produce this number of ampere-turns.

The resistance of a conductor is equal to the product of 10.8 and the length in feet, divided by the sectional area in circular mils, so that when considering the resistance of the winding of a field coil, the following formula will apply:

$$R = (10.8 \times L' \times N) \div a$$

Where R is the resistance in ohms, L′ the length of the mean turn, as explained in Fig. 14, but expressed in feet, N the number of turns employed and a the sectional area of the conductor in circular mils.

For any particular machine the coil will receive current under some given voltage E, from the value of which, together with that of R, we are, by the application of Ohm's law, readily enabled to calculate the value of the current flow. Current or I is equal to the quotient obtained by dividing the voltage E by the resistance R, and as we have just seen, R is equal to $(10.8 \times L' \times N) \div a$.

$$I = \frac{E}{(10.8 \times L' \times N) \div a}$$

or

$$I = \frac{E\,a}{10.8 \times L' \times N}$$

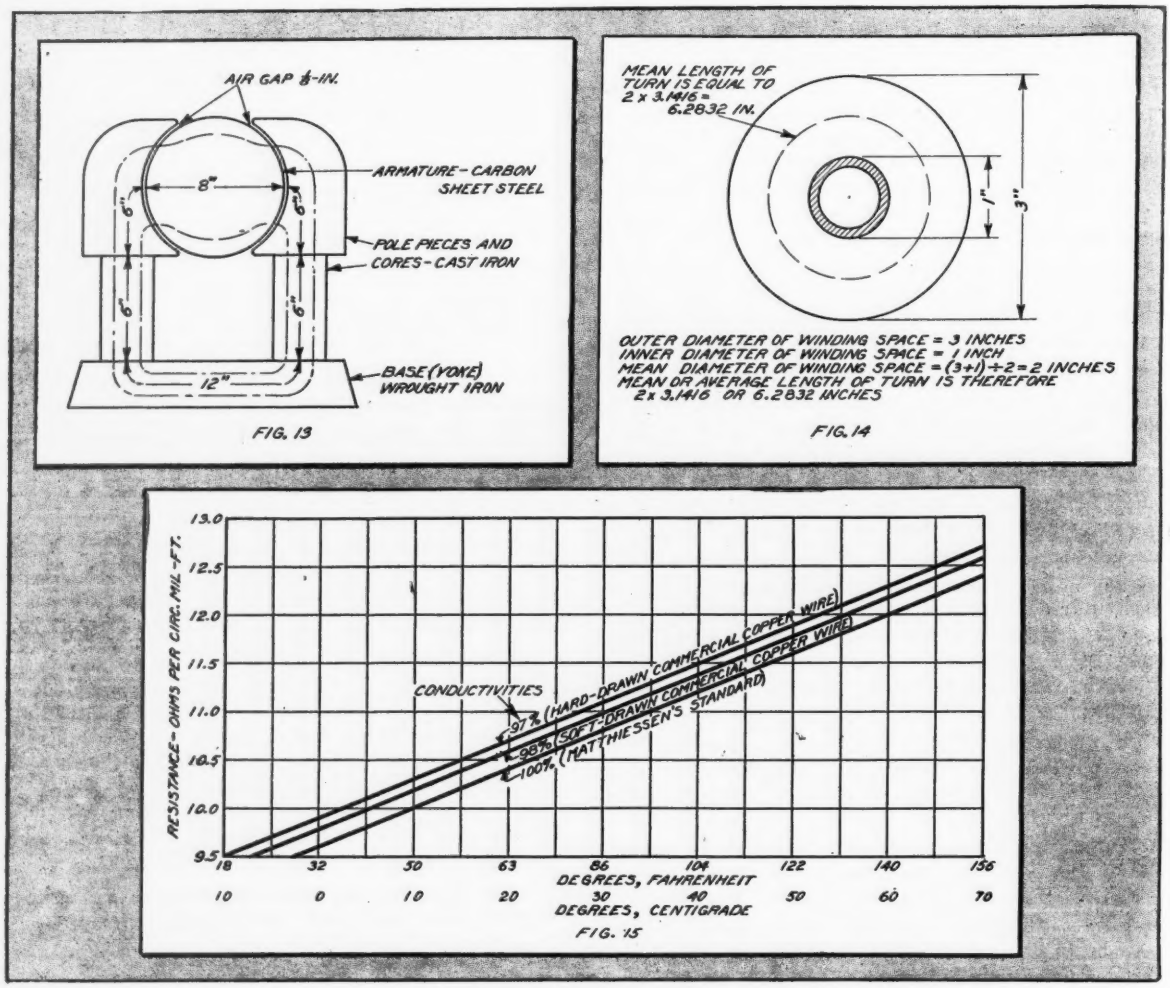


FIG. 13. ILLUSTRATING THE MAGNETIC CIRCUIT OF A TYPICAL BIPOLAR DYNAMO

FIG. 14. EXEMPLIFYING MEAN LENGTH OF TURN

FIG. 15. CURVES SHOWING CHANGE IN SPECIFIC RESISTANCE WITH CHANGE IN TEMPERATURE FOR VARIOUS GRADES OF COPPER WIRE

Multiplying each side of this equation by N, the value of the number of turns, we have

$$I\,N \text{ (ampere turns)} = \frac{N\,E\,a}{10.8 \times L' \times N}$$

But, as N appears in both the numerator and the denominator of the right-hand side member of the equation, these cancel as follows:

$$I\,N \text{ (ampere-turns)} = \frac{E\,a}{10.8 \times L'}$$

Transposing, we have a, or the sectional area of the

$$\text{conductor} = \frac{10.8 \times L' \times I \times N}{E}$$

Provision for Heating

In presenting the formula for calculating the resistance of a conductor, p or specific resistance was accepted to have a value of 10.8 ohms. This, however, as may be seen by reference to the curves in Fig. 15, showing the resistance per circular mil foot of copper of different conductivities at various temperatures, is the resistance of a 1-ft. length of soft drawn commercial copper having a diameter of 1 mil, when at a temperature of about 75 deg. F. Obviously then, the above formula for the size of wire required for any particular coil is based upon a working temperature of 75 deg. F.

Should it be desired, therefore, to work the coil at any other temperature, the value of the specific resistance of the grade of copper employed at that other temperature will have to be used instead of 10.8. Assume we desire to use a working temperature of 131 deg. F., and that the wire is of the soft commercial grade. The specific resistance to be used in our calculations will then, according to the curve, be 12.

Rate at which heat is generated in any wire is proportional to the square of the current and to the elapsed time; that is $H = R I^2 t$.

Where H is the amount of heat generated by current I, R the resistance of the wire and t is the time in seconds. And, as the temperature rise within a coil is not only dependent upon the value of H, but also upon the amount of external surface exposed to the air, at least 1 sq. in. of radiating surface should be provided for each ½ w. of $R I^2$ loss.

(To be continued)

Three-Phase Four-Wire Distribution

Advantages and Disadvantages to Be Realized and Probable Troubles and Their Prevention. By G. E. Wagner

THREE-PHASE current was at first distributed over three-wire circuits. In this system transformers for lighting purposes are connected between any two lines and for three-phase power they are connected in delta on both primary and secondary side. This connection is shown on Fig. 1 and is generally referred to as the delta-delta connection.

Shortly before 1900, three-phase, four-wire distribution was developed, increasing the line voltage, thereby reducing the size of wire and the amount of copper required, and still permitting the use of the same step-down transformers used for the three-wire system. In this system, the transformers for polyphase use are connected in star on the primary and in delta on the secondary side, Fig. 2, generally called the star-delta connection. The voltage on the transformers is the same as on the three-wire system and therefore the secondary voltage is also the same. For single-phase use transformers are connected between a phase wire and the neutral, as shown in Fig. 3, the neutral point being grounded.

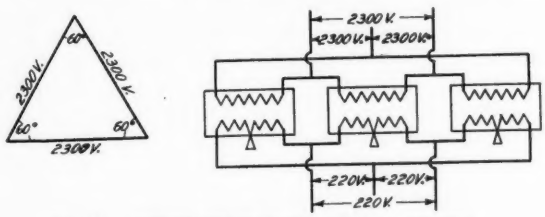


FIG. 1. THREE-PHASE DELTA-DELTA SYSTEM

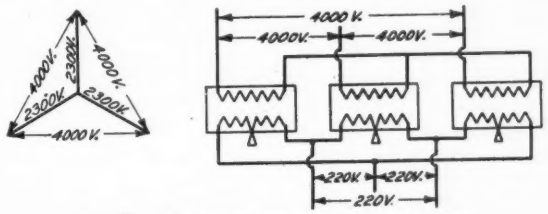


FIG. 2. THREE-PHASE STAR-DELTA SYSTEM

Since 1900 the three-phase, four-wire system has been adopted by many cities which have remodeled their distribution system or have developed new systems.

At the present time there are still three methods of distributing high-voltage alternating current, namely: single-phase, two-phase and three-phase. In both two-phase and three-phase there are three-wire and four-wire systems. In comparing these various methods of distribution it is essential first to consider the first cost, the largest item of which is the copper. Assuming the weight of copper required for a single-phase circuit as 100 per cent, the amount of copper required for the various systems for the same load would be as follows:

Single-phase system	100 per cent
Two-phase four-wire system	100 per cent
Two-phase three-wire system	73 per cent
Three-phase three-wire system	75 per cent
Three-phase four-wire system	33 per cent

The above tabulation assumes that the same step-down transformers will be used with all the systems; i.e., that the voltage between conductors, in case of single-phase, two-phase four-wire and three-phase three-wire-systems is the same as the voltage to neutral of the three-phase four-wire system. Hence in the three-phase four-wire system the voltage between phase conductors is increased $\sqrt{3}$ times, requiring only one-third of the copper of a three-phase three-wire system or 25 per cent of a single-phase circuit carrying the same amount of power. This, however, does not include the fourth or neutral wire. If this wire has a section equal to either of the three-phase wires, the copper is increased from 25 to 33 per cent.

The three-phase, four-wire distribution in general use is the 2300/4000-v. system, so called because the voltage between any phase wire and the neutral point or neutral wire is about 2300 v. and between phase wires 4000 v. Since the voltage to neutral is the same as was used for the three-wire system, the same transformers can be used.

Since the line voltage in the four-wire system is 1.73 times that of the three-wire system, the line current is proportionately less and the line drop is directly proportional to the line current, it follows that the size of wire required for the same load and with the same permissible loss is 1/3 of that required for three-wire distribution. It follows that if a three-wire circuit is converted into a four-wire circuit the capacity of the circuit is tripled. If this circuit is to supply any individual single-phase transformers, however, then the fourth or neutral wire should be strung in. It is possible to use the ground as the neutral return, but it is more satisfactory to use a fourth wire.

From the above it also follows that if two single-phase circuits are combined into one four-wire three-phase circuit, the capacity of the three-phase circuit is three times that of the two single-phase circuits combined. For example, the amount of electric energy will be calculated that can be transmitted a distance of 5000 ft. over No. 2 copper wire with a line drop of 92 v. between the generator and the load, the phase voltage to be 2300 v. The resistance of No. 2 copper wire is 0.156 ohms per 1000 ft., and the resistance of one single line would be five times that or 0.78 ohms.

In a single-phase circuit the drop in voltage would be twice the drop in one line. Assuming that only the

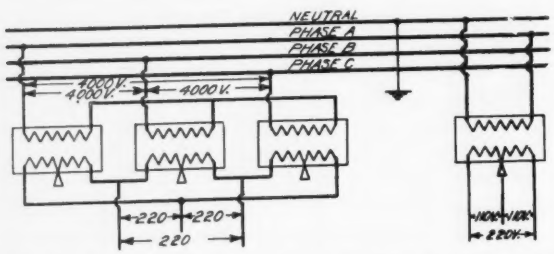


FIG. 3. THREE-PHASE FOUR-WIRE SYSTEM SHOWING BANK OF THREE SINGLE-PHASE TRANSFORMERS AND ONE SINGLE-PHASE LIGHTING TRANSFORMER

resistance drop is considerable, the circuit would then transmit $92 \div (0.78 \times 2)$ or 58.9 amp., or about 135 kv.a.

In a three-phase, three-wire circuit, the drop in voltage would be 1.73 times the drop in one line. A circuit of No. 2 wire would then transmit $92 \div (0.78 \times 1.73)$ or 68.2 amp., or about 270 kv.a.

In a three-phase four-wire circuit with a balanced load, the drop in voltage would be the drop in one line only. This circuit will then transmit $92 \div 0.78$ or 118 amp. or about 810 kv.a.

Since the number of wires required for the above systems are 2, 3 and 4, respectively, the amount of copper required under the three conditions would be in the ratio of 2 to 3 to 4. The calculations show, however, that the amount of power that can be transmitted varies in the ratio of 2 to 4 to 12.

While the increased line voltage is advantageous in so far as it requires less copper it must be viewed from another angle not so beneficial. If branches of trees are permitted to extend through the line between phase wires, they will cause leakage, particularly in wet weather, frequently causing one or more wires to burn off. For the same reason, larger line insulators are usually required. The increased voltage must also be taken into consideration on underground work. The grounded neutral and increased line voltage must also be considered in the choice of lightning arresters. On account of the grounded neutral, a ground on a phase wire will cause a short-circuit.

In both three-wire and four-wire systems it is possible to supply three-phase current from two transformers only, with an open delta secondary. If only two transformers are used on a four-wire circuit the middle point of the transformer bank must be connected with the neutral wire. Without this connection the two transformers would simply be in a series across 4000 v. and would deliver a single-phase current only. Either the primary or the secondary of one transformer must also be reversed, to secure the proper phase relations.

When three transformers are used on a four-wire circuit, the neutral point of the transformer bank should be isolated, except in special cases; that is, it should have no connection with the neutral wire of the circuit or the ground.

Some companies have tried to connect the primary neutral point of transformer banks which supplied a comparatively large single-phase load in addition to a three-phase load, to the neutral wire, a larger transformer being installed in the phase supplying the single-phase load to take care of the unbalance. The primary neutral wire was connected with the idea that it would take care of the excess primary current for the larger transformer instead of having it pass through the windings of the smaller transformers. An example of this condition would be a consumer requiring single-phase current for spot welders and three-phase current for a few motors.

Laboratory tests have demonstrated that under the conditions cited above the primary neutral carried practically no current. The tests showed that if a single-phase load is supplied from one phase of a three-phase bank of transformers, the other two transformers act as one single-phase transformer operating in parallel with the one on the loaded phase and share the load with it. The oscillograph showed that the current through the primary windings of the large transformer divided and part of it passed through the primary winding of each of the other two transformers. The current waves of the current in the two transformers were about the same, exactly in phase and just 180 electrical degrees from the current in the transformer on the loaded phase.

These tests also showed that the current in the neutral wire was practically zero so long as the voltages were balanced. As soon as the voltages were unbalanced in the secondary delta a circulating current was set up in the delta and there was a flow of current in the neutral wire of the primary current.

When a single-phase load was supplied from one phase of delta connected secondaries, during these tests, the load was distributed over the three transformers, the transformer on the loaded phase supplying about one-half and the other two together the other half. The exact proportions of the load supplied by each seemed to depend upon the power-factor of the circuit. The tests also showed that the three transformers divided the single-phase load in about the same proportion

whether the primary neutral was connected or isolated.

The results of these tests were verified in the field on a bank of transformers supplying a 200-amp. three-phase load, and in addition two 100-amp. spot welders from one-phase. Every time a spot welder came on it drew current from all three transformers. The current in the neutral caused by the welders coming on was practically nothing. A comparatively heavy current was set up in the neutral wire, however, when the operator at the station varied the voltage on one phase with the feeder regulator.

From the foregoing it follows that in a bank of transformers to supply three-phase power and an additional single-phase load there is no occasion for installing one transformer with a capacity larger than the capacity of the other two combined. Inasmuch as the neutral wire carries practically no current there would be, under such conditions, an excess current in the windings of one or both of the smaller transformers, if the larger transformer carried full load. In determining the sizes of transformers necessary for an installation like the above it should be borne in mind that the transformer on the phase supplying the single-phase load actually supplies only about one-half of the single-phase current while the other two supply the balance.

From the above it also follows that the primary neutral point of three-phase transformer banks should be isolated unless the transformers have ample capacity to take care of their regular load plus any circulating current that may be set up on account of an unbalanced voltage condition. If one-phase wire should develop a ground the voltage on that phase would naturally drop on account of the heavy current. The transformer bank with the primary neutral connected would immediately tend to equalize the voltages on the three phases. The other two transformers would draw a heavy current on

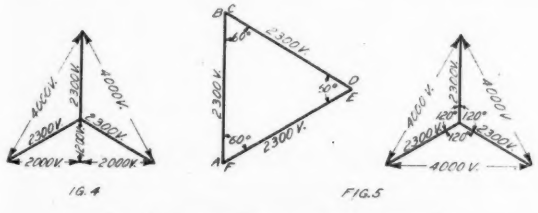


FIG. 4. DISTORTION OF STAR SYSTEM

FIG. 5. VOLTAGE MAGNITUDES AND RELATIONS IN THE DELTA AND STAR SYSTEMS

their phases trying to boost the voltage on the grounded phase. The probable result would be that the primary fuse of one transformer would blow and the other two would then carry the load on open delta. If the capacity of the other two transformers was insufficient they would be overloaded and would be liable to be damaged.

If the primary neutral point of a transformer bank is isolated, there is no circulating current caused by unbalanced voltages, but if one blows a fuse the other two transformers are actually in series between two phase wires. Their secondary voltages are then one-half of the normal voltage times 1.73 (about 200 instead of 230) and the voltage across the secondary and primary of the transformer with the fuse blown is zero when the load is straight resistance or single-phase load. If there are any three-phase motors on the circuit they will run and their windings will tend to keep up a delta voltage. If these motors are stopped they will as a rule not start because it would be equivalent to trying to start them on single-phase current.

One of the greatest advantages of three-phase four-wire distribution is its successful use for both light and power purposes regardless of load balance. If a single-phase feeder regulator is installed in any phase, it can be adjusted to give a constant voltage at any point on the line regardless of the load on the other phases. In fact, one method of developing a four-wire circuit is to supply all the single-phase lighting load from one phase and equip this phase with a feeder regulator. When the lighting load increases it can be distributed

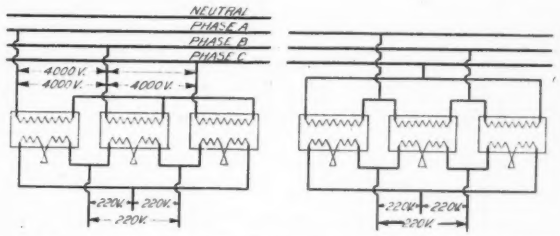


FIG. 6. TYPICAL THREE-PHASE FOUR-WIRE AND THREE-PHASE THREE-WIRE SYSTEMS

over all three phases and feeder regulators installed in them.

On account of the simplicity of voltage regulation a three-phase, four-wire circuit can be used for supplying all the current for any district, whether it is used for lighting, heating or power. It thereby overcomes the necessity of paralleling circuits and investment for any district. Supplying current for both lighting and power purposes also increases the load factor on the circuit, because the power load is generally quite low before the lighting peak comes on.

In three-phase, four-wire distribution, individual transformers for lighting purposes are connected between any one phase wire and the neutral wire. If a number of such transformers are distributed over the three phases there is a possibility of trouble from another source. Under this condition the current in the neutral wire is the vector sum of the current in the phase wires. If the neutral wire should open between the station and the load, an unbalanced load on the phases would cause an unbalance in voltage which might be disastrous to lamps burning in the circuit at the time.

The current in the primary winding of a transformer increases as the secondary current increases because the actual reactance in the primary decreases. Therefore if two phases were heavily loaded and one phase had almost no load and the neutral wire was broken, the difference in reactance would cause the neutral point of the circuit to be drawn out of center, as indicated by voltages in Fig. 4. The transformers on the loaded phases would then practically be in series between phase wires and would deliver a secondary voltage of nearly 100 and 200 instead of 110 and 220 v. The transformers on the phase carrying very little load would have a voltage of about 3500 v. impressed upon their primary and their secondaries would deliver 175 and 350 v. instead of 110 and 220 v., with the probability of burning

out some lamps. In Fig. 4 the correct voltages are indicated by full lines and the distorted voltage condition is shown by the dashed lines.

The probability of such a case of trouble is quite remote. The effect of such an occurrence can be reduced by carefully distributing individual lighting transformers over the three-phase with a view of keeping the load fairly well balanced. The possibility of such a case of trouble can be overcome by supplying all of the single phase lighting transformers from one phase, but the most satisfactory method of overcoming this danger seems to be to ground the neutral wire not only at the station but at several places along the line. The ground connections would serve as a path in parallel with the neutral wire and if the neutral wire broke down anywhere the ground would take care of the unbalanced load and prevent sufficient distortion to do any damage. Special care should be taken in the selection of the points for grounding to guard against picking up stray currents. It would be an aid in this direction to connect the neutral wires of different circuits as a guard against having any entirely down at any time. The neutral wire should never be fused and should have no switches, except four-pole, which will open all four wires at once.

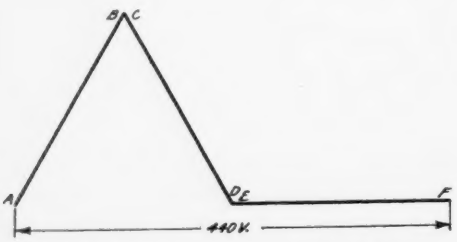


FIG. 7. EFFECT OF REVERSING PHASES ON SECONDARY DELTA

In changing from three-phase, three-wire to three-phase, four-wire distribution the first consideration is, of course, the higher voltage generator. If the winding of a 2300 v., three-phase generator is connected in delta, it can be used for 4000 v. If the generator is already star connected it would have to be rewound, or delta-star transformer used.

The all important requirement on the line is to make sure that when the change is made in the transformer for connections the phase relations will not be changed, in order that the rotation of three-phase motors will not be reversed. Figure 5 shows the change from delta to star connection which will not disturb the phase relations. Figure 6 shows the actual change in connections in the field in changing a bank of transformers from delta-delta to a star-delta. The connections on the secondary side are not disturbed. The simple rule is that all the right hand primary side or all the left hand primary side are connected to the neutral point and the other sides are connected to phase wires.

It might be well to caution against reversing the secondary side of any one transformer in connecting a new bank. Such a connection would produce a short-circuit on a voltage equal to twice the phase voltage. This condition is shown in Fig. 7. An attempt to close the secondary delta with the primary current on it would cause a short-circuit on 440 v.—THE ELECTRIC JOURNAL.

Improvements in Electrical Contacts

By J. H. BLAKEY

SEVERAL recent French patents refer to developments in electrical contacts. Patent No. 484,271 of the French Westinghouse Co. relates to contacts in relays, circuit breakers, etc. Tungsten and molybdenum have been used as substitutes for platinum, but have certain disadvantages. For example, they oxidize easily, and the oxides when formed are practically non-conducting. On the other hand, silver, when used as a cathode is apt to become roughened on account of its low fusing point. In this patent it is accordingly suggested that the anode should be of silver, platinum or iridium—metals whose oxides conduct relatively well—and the cathodes of tungsten or molybdenum, which have a high fusing point.

Another device, described in patent No. 484,287, taken out by the Oerlikon Co., has for its object the automatic reversal of the polarity of contacts, to prevent the transfer of metals from one pole to the other. The passage of the current automatically brings about the reversal, the period of which is determined by an ampere-hour meter.

SINCE the periodicals of the country have been carrying the information that the Federal Board for Vocational Education was prepared to offer retraining to disabled soldiers, sailors, and marines, the response has been immediate. Many men who had gotten out in civil life, and were endeavoring to "carry on," often under grievous handicaps, have learned that they may have their disabilities neutralized by special training and be comfortably supported while this is being accomplished, with their dependents adequately cared for during the period, and with a certainty of employment at the completion of the course, if the training is for a wage earning occupation.

Since the co-operation of the publications has been tendered the Federal Board, 4725 men have made application for the training, and in a large percentage of these cases the men attributed their contact with the Federal Board to information they had gained by reading periodicals. Other agencies in various communities of the country have been stimulated into activity by the same means, and 1765 disabled men have been brought in contact with the Federal Board in this way, traceable directly to the influence of the periodicals in interesting individuals and local societies in the welfare of disabled men of the various neighborhoods. These figures are only to April 1, and at the rate applications have been coming in to the Federal Board, it is evident that the work of the periodicals is bearing abundant fruit.

A PRODUCTION of 314,936 tractors in the United States in 1919 is estimated by manufacturers reporting to the Office of Farm Equipment Control, United States Department of Agriculture. The reports obtained in a special inquiry by the department show a production of 132,697 tractors in 1918. The manufacturers gave the number of tractors of different sizes manufactured last year and estimates of the number of each size that will be made this year. The figures for 1919, of course, are merely estimates and represent the aggregate of the estimates submitted by the tractor manufacturers in January and February of this year.

Engineer Portable Shop Train

DETAILS OF EQUIPMENT FURNISHED UNITED STATES ENGINEER TROOPS IN FRANCE. BY PHILIP C. NASH

IN 1917, the Board on Engineer Equipment of the Corps of Engineers, United States Army, designed a train of four portable shops, each mounted on a five-ton Mack truck. Maj. O. B. Zimmerman was responsible for the arrangement of the shops, for the machines and equipment installed, and for the practical working out of the idea. Six complete trains were sent across to France in August, 1918, and there were numerous other calls for the unit which had not been filled when the Armistice was signed. A considerable number of the shops were used at Camp Humphreys and Washington Barracks for the training of Engineer troops in the trades covered by the shops.

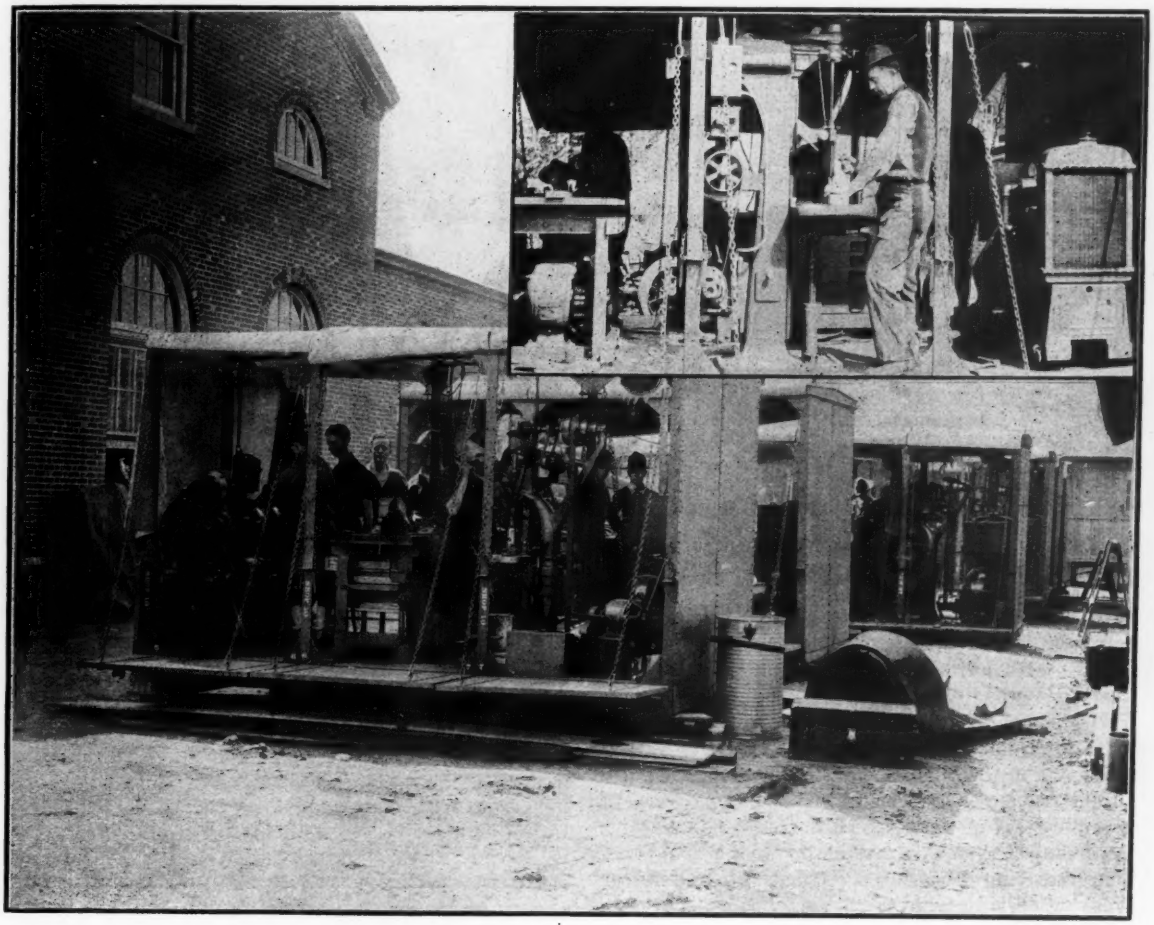


FIG. 1. AT WORK IN PORTABLE MACHINE SHOP AT WASHINGTON BARRACKS

The train consists of the following shops: Machine, Carpenter, Blacksmith and Material. Each of the first three shops contains a complete power plant, consisting of a four-cylinder 1000-r.p.m. Winton motor and a five-kw. d.c. generator. This power plant is entirely independent of the truck on which the body rests, and by having the three plants it is possible to join them so as to get sufficient power to run any or all of the machines simultaneously.

The Material Shop contains a supply of hammers, drills, shovels, picks, wrenches, hatchets, chisels and stocks and dies. Besides these tools there are 25 lb. of babbit, a large assortment of bolts and nuts, explosive supplies, hacksaw blades, spare handles, 275 ft. of hose, a supply of bar iron and steel of assorted shapes and sizes, nails, oil, packing, pipe, rivets, rope, screws, sheet metal, steel wedges, washers, wire etc. That is to say, on this truck can be found tools and supplies for almost any of the Engineer duties.

The Carpenter Shop contains two boring machines, one drill press, one bench and grinder, one circular saw and bench, one power plant with complete switchboard, one winch and one work bench. The arrangement is such that all the machines can be operated without removing from the position in the shop, but to allow more space and freedom they are usually removed unless train is to move shortly. There is a large supply of

various carpenters' tools and supplies in this shop, including adzes, augers, bits, blocks, chisels, drills, files, hammers, hatchets, two jacks, levels, planes, pliers, saws, squares, vises, chalk, extra gasoline drum, spare handles, 100 lb. nails, screws, tacks, etc.

The Blacksmith Shop contains work bench, anvil, two forges, two chain hoists, two pipe threading machines, one shear and punch, and one oxy-acetylene welding and cutting outfit, and one power plant and switchboard. This shop is designed to be a combined blacksmithing, horseshoeing, plumbers', pipe fitters' and sheet metal workers' headquarters. It is not feasible to do all these different things in the shop as mounted on the truck. The combination used somewhat at Washington Barracks was to have oxy-acetylene and blacksmith work in the shop and the other trades outside, or in adjacent buildings.

The following list of tools and supplies included in the shop is not complete, but it gives an idea of the contents: Leather aprons, chisels, dies, drills, files, plumbers' furnaces, hacksaw frame and blades, hammers, pipe cutters, pliers, punches, soldering coppers, shears, tongs, gasoline torches, wrenches (monkey, Stillson and chain),

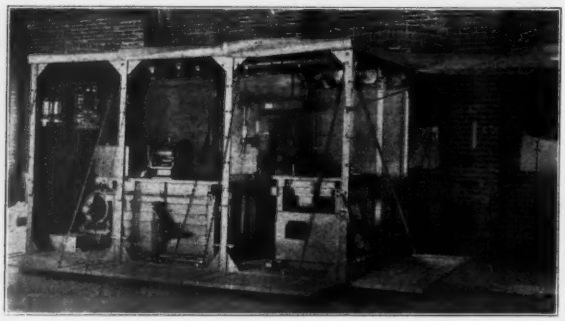


FIG. 2. CARPENTER SHOP UNMOUNTED AND READY FOR WORK

assorted bolts, coal, bushings, tees, caps, valves, couplings, plugs, ells reducers, flanges, nipples, packing, rivets, etc. Plumbers' supplies include 6-in. cast-iron and smaller wrought-iron fittings.

The Machine Shop is the most complete and most useful shop from a civilian point of view.

As shown in the photograph, the machines are bolted to a solid wooden floor, which has dimensions when the sides are lowered of 15 ft. by 11 ft. 3 in. The machines are so arranged that it is possible to work around them without removing from the shop, but for winter work at Washington Barracks it was found more convenient to put the machines in a heated building.

The principal tools are a 14-in. Leblond lathe with 5-ft. bed, driven by a 2-hp. 110-v. motor, an 18-in. drill press, motor driven, a motor-driven grinder, 10-in., two-wheel, 2000-r.p.m., a work bench with vise and drawers, an electric portable drill, two electric portable hammers, one complete oxy-acetylene welding and cutting outfit, a 1000-lb. Yale triplex hoist, power plant and switchboard complete. There are besides these a full complement of arbors, calipers, chisels, drills, files, hammers, jacks, lathe tools, dogs and mandrels, reamers, sleeves, scribers, soldering materials, taps and dies, high-speed tools and tool holders, wrenches, emery cloth and abrasives, babbit metal, bolts, brushes, lanterns, fire extinguishers, screws and steel bars of assorted grades, shapes and sizes.

The shop is electrically lighted and wired so that all machines can be easily cut in or out.

The cost of the complete outfit, including truck, body, tools and supplies, is about $8500 at war prices. The weight is about 11,000 lb.

It was found at Washington Barracks that this machine shop is sufficient to handle the repair work of a

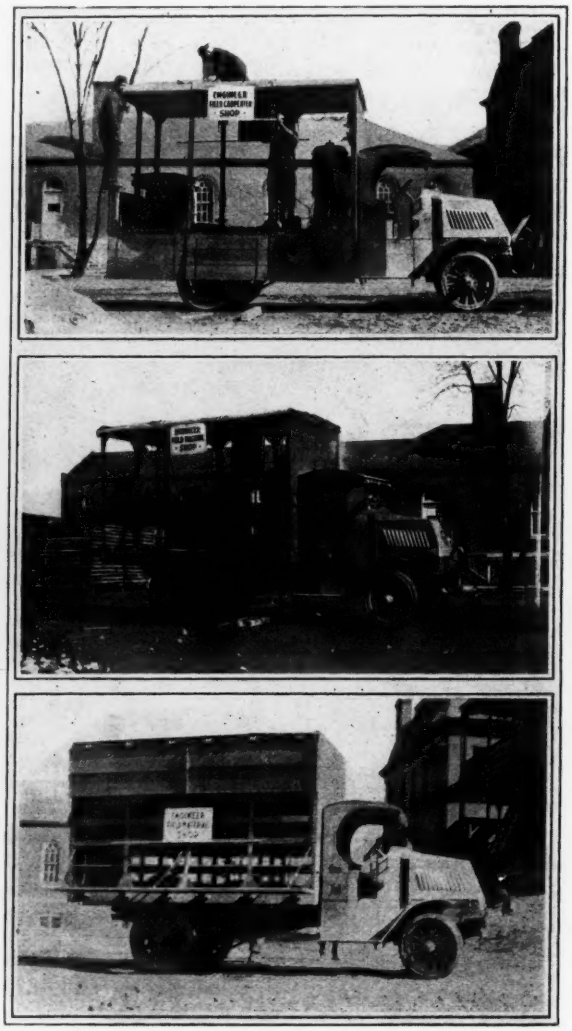


FIG. 3. PORTABLE SHOPS READY FOR TRANSPORTATION

considerable number of machines and the usual machine shop work necessary around the post, and it is suggested that this outfit would be of great value to construction contractors, allowing them to have a machine shop at all times on the job, thereby saving much expense at local machine shops and time in making small repairs. Its permanent usefulness will possibly be even greater, however, in the fair sized industrial plant where portability is a factor.

Following is a more detailed list of the equipment provided these shops:

PORTABLE MACHINE SHOP

MACHINES

Item.	Quantity.	Articles.
1	1	Bench, work.
2	1	Drill, portable electric.
3	1	Drill Press, 18 in.
4	1	Grinder.
5	5	Hammers, electric.
6	1	Lathe, 14 in.
7		Tools for hammers (No. 5).
	2	¾ by 12-in. drills.
	2	1 by 12-in. drills.
	2	Chisels.
8	1	Power Plant, complete.
9	1	Switchboard.
10	1	Welding and Cutting Outfit, portable, oxy-acetylene.

TRUCK AND BODY

1	1	Standard Commercial 5-Ton Truck.
2	1	Truck Body.

TOOLS

1	to 89	Complete set hand, bench and lathe tools.

SUPPLIES

1	to 23	Including abrasives, babbit metal, belt lacing, bolts, extension lamp cords, fire extinguisher, first aid set, lanterns, markers, oils, packing, saw sets, screws, steel bars and storage receptacles.

PORTABLE CARPENTER SHOP

MACHINES

Item.	Quantity.	Articles.
1	2	Boring Machine.
2	1	Drill Press, 16 in.
3	1	Grinder Bench.
4	1	Power Plant, complete.
5	1	Saw Bench.
6	1	Switchboard, ebony asbestos, fitted with the following instruments: One 150-volt voltmeter; one 75-amp. ammeter; one field rheostat; one 60-amp. D. P. S. T. main line switch and fuses; one Ill. light; one lighting circuit; four 30-amp. power circuits, switches and fuses.
7	1	Winch, double purchase, 6 by 21 in.
8	1	Work Bench, 2 ft. 3 in. by 5 ft. 6 in. over all.

TRUCK AND BODY

1	1	Standard Commercial 5-Ton Truck.
2	1	Truck Body.

TOOLS

1	to 51	Including full set hand, wood working tools, rules, tapes, vises, etc.

SUPPLIES

1	to 20	Including nail bags, buckets, chalk, fire extinguisher, first aid outfit, gasoline, awl handles, axe handles, lanterns, nails, oil, pencils, screws, tacks and wedges.

PORTABLE BLACKSMITH, PLUMBING AND TIN SHOP

MACHINES

Item.	Quantity.	Articles.
1	1	Bench, work.
2	2	Forges, blacksmith, portable.
3	1	Hoist, chain—2-ton, 9-ft. lift.
4	1	Hoist, chain—5-ton, 12-ft. lift.
5	1	Pipe Threading Machine, portable—to take 2½ to 6-in. pipe.
6	1	Pipe Threading Machine, portable—to take 1 to 2-in. pipe with extra set of dies.
7	1	Shear and Punch combined.
8	1	Vises, combination machinist's and pipe.
9	1	Welding and Cutting Outfit.
10	2	Windshields for use around forges.
11	1	Power Plant.
12	1	Switchboard.

TRUCK AND BODY

1	1	Standard Commercial 5-Ton Truck.
2	1	Truck Body.

TOOLS

1	to 57	Including complete equipment of blacksmith's, plumber's and tinner's tools.

SUPPLIES

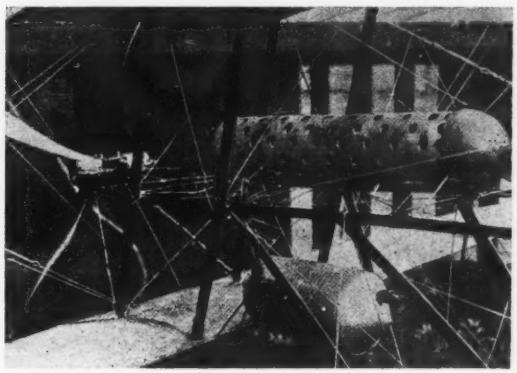
1	to 26	Including muriatic acid, borax, bolts, buckets, oil can, coal, boiler compound, welding compound, grease cups, fire extinguisher, first aid pack, pipe fittings, packing, etc.

Are Steam-Propelled Aircraft Possible?

UNTIL just a few years ago flying was popularly regarded as a dangerous hobby and comparatively few had faith in its practical purposes. But the phenomenal evolution of the aircraft industry during the war brought progress which would otherwise have required a span of years. With the cessation of hostilities, considerable attention has been diverted to the commercial uses of aircraft, which may conveniently be classified as mail and passenger service.

Men who first ventured the prediction that postal and express matter would one day be carried through the air were branded as dreamers. Parts of that dream became a reality during 1918, and a more extensive aerial mail program will be adopted this year. The dispatch with which important communications and parcels are delivered between large cities has firmly established its need.

Large passenger-carrying aircraft are now receiving pronounced attention. Lately developed by the Navy is a flying boat having a wing area of 2400 sq. ft.



STEAM PLANT IN MODEL AIRPLANE

equipped with three Liberty motors and weighing 22,000 lb. with a full load. It is the largest seaplane in the world, and on a recent test trip from Virginia to New York carried 51 passengers. At the present moment the public is awaiting the thrilling details of the first flight between Europe and America, which has just occurred as a result of the keen international rivalry involved between the various entrants.

The British are now constructing a super-triplane fitted with six 506-hp. engines. Originally intended to carry 10,000 lb. of bombs and a crew of eight over a distance of 1200 mi., the converted machine is claimed to be able to carry approximately 100 passengers. It has a wing span of 141 ft. and a fuselage length of 85 ft.

What about the power plants of the future aircraft? Will the internal combustion engine continue to reign supreme, or will increasing power demands of the huge planes to come lead to the development of suitable steam engines? Will the use of petroleum continue to be one of the triumphs of aviation or will the time come when substitutes may be successfully utilized?

For aerial motive power, the principal requirements are: great power for weight with a fairly high factor

of safety, compactness, reliability of operation under flying conditions, and safety from fire. Bulk and weight of steam-driven equipment apparently impose severe restrictions upon its practical development for present aircraft purposes, but who is willing to classify its future use as an absurdity?

Steam operation in small model airplanes is no innovation. Langley, in 1891-95, built four model airplanes, one driven by carbonic acid gas and three by steam engines. One of the steam-driven models weighed 30 lb. and on one occasion flew a distance of about 3000 ft. In 1913 an Englishman constructed a power plant, weighing about 2 lb., which consisted of a flash boiler and single-acting engine. This unit employed benzoline, impure benzine, as fuel and propelled a model plane weighing 5 lb. The illustration shows the steam plant mounted in a model plane, the fuel tank being below the flash boiler and the engine placed directly at the propeller.

Upon turning over a page of a 1969 issue of Power Plant Engineering, a reader may possibly view these headings:

"Notes on draft regulation at 10,000 ft." "New Government rules on discharge of cinders from air liners." "What would you do if the water failed to return to the gage after looping the loop?" "Advantages of clouds for feed water," and "Factors influencing design of boilers for aerial service."

Puffs From the Exhaust

By C. H. Stephen

A SMILE before breakfast clears away
The petty annoyances of the day.
A cheerful heart is the biggest boom
That ever enters an engine room.

The pump that keeps the boilers full
Is long on push and short on pull.
Economics will capture "the missing link"
When labor and capital rightly think.

The greatest work is not done, I've found,
By the engine that has the loudest pound.
A workingman who defies the laws
Is a dangerous asset to labor's cause.

The power of commerce on steam relies,
But only the steam that's used applies.
The man that uses what little he knows
Is the kind of fellow that always grows.

There is no value at all in coal
Until it passes the furnace hole.
A ton of knowledge may help us some,
But the pound we use is what makes things hum.

The governor pulley, though mighty small,
Makes the belt wheel answer its beck and call.
The little fellow who does his best
Is as great as the biggest man, by test.

The common sense that conquers strife
Is the governor belt of a useful life.
An engineer, to do his part,
Must keep the valves tight in his heart.

Success means meeting life's tasks with cheer,
And faithfully filling your chosen sphere.
The man who's afraid of doing too much
Is a chosen inmate of poverty's clutch.

The greatest power in the human plan
Is the gift of helping your fellow-man.
A little brain, put to proper use,
Will save the world from vast abuse.

The mind of the working man should be
The governor shaft of his destiny.
If your brain won't work, and you must be led,
See your leader carries a level head.

The man who's too big for the job he holds
Very rarely his wondrous worth unfolds.
When man starts to think he is apt to find
That lack of thinking has cramped his mind.

The man who fills his allotted space
May grow big enough for the boss's place.
No matter what knowledge you have attained,
It was by the help of others gained.

If you by men would be counted fair,
You must with others your knowledge share.
The throttle of progress is human will,
When that is closed the world stands still.

To read and study what others say
Makes a fitting close for a perfect day.
A real big man oft feels so small
That he never sees himself at all.

An engineer with a smiling face
Is a decoration in any place.
Success is a dangerous steed to ride
When fed on the stubble of bloated pride.

A crank is useful, we must admit,
But when in motion, steer clear of it.
A grouch is a misfit out of place,
A cancerous growth on Nature's face.

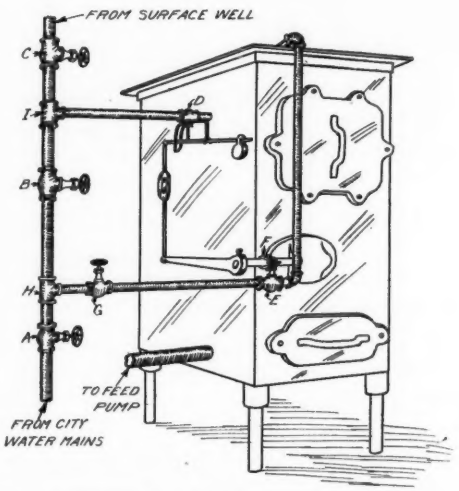
Don't stop to envy the other man;
Use all you know the best you can,
And you will find as you proceed
That time will care for your every need.

It is not generally known that the Federal Board for Vocational Education maintains a course designed to prepare disabled soldiers for civil service positions. There are 32 men now studying to qualify themselves for positions under the civil service, and the Board will undertake to prepare any student who so desires, provided he can qualify as physically competent to do the work. Of course there are some regulations regarding these positions and men obviously handicapped cannot expect to hold down jobs where their physical disqualifications are such as to prevent the proper discharge of the duties. But on April 16 the President authorized an amendment to the civil service rules which permits the civil service commission to exempt from the physical requirements established for any position, a disabled and honorably discharged soldier or sailor or marine upon the certification of the Federal Board for Vocational Education that he has been specially trained for and has passed a practical test, demonstrating his physical ability to perform the work sought. Under the law a disabled soldier has a preference on the civil service list of eligibles.

Heater Supplied From Two Sources

OWING TO the hardness of our city water we recently drove a 3-in. surface well for supplying our boilers.

We drive the pump in the surface well from a line shaft belted to the air compressor. The surface well discharges directly into the heater under a pressure of about 20 lb., with an overflow pipe for surplus water to go to the reservoir. We arranged the piping this way to save the cost of a tank. After we had everything in working order, we found that the fireman would run his



PIPING ARRANGEMENT FOR SUPPLYING HEATER WITH WATER FROM TWO SOURCES

feed-water pump faster at times than the surface well could supply the water, so we arranged an auxiliary supply for the heater which would work only when the feed-water pumps would take the water from the heater faster than the surface well would supply. This supply or deficit comes from the city mains. The sketch shows the piping arrangement.

The original piping arrangement consisted of a supply pipe from city mains to the heater through the balanced valve, D. When the surface well was installed we put a tee at I and installed the valve, C. The unique feature of the installation is the use of the float arm to make up the deficit in the supply when needed, which was done in this manner. I installed the valve, B, and a tee at H, where I reduced piping to ¾-in. and arranged it so that I could install a valve, E, about 2 in. from the float arm. The valve used is a common globe valve, with the threads filed off the stem so that it could be lifted. The valve was installed with city pressure on top of seat. To manipulate this valve I bent a piece of strap iron, F, to fit the float arm or shaft and clamped it to the shaft with a stove bolt, letting the ends extend out so that the upper one would close the valve when the water rose to the proper height in the heater, and when it fell below a fixed place, the lower projection will open the valve and supply the needed amount. The lower projection is split so that a finger on either side of the valve stem gives an even lift to the stem. The wheel was removed and a couple of cut washers were fastened on the stem in its place. This extra supply of water is discharged into the heater from the top, and just above where the regular supply pipe enters.

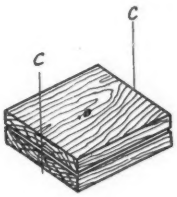
This emergency device gives excellent service and has saved us the price of tank for boiler water.

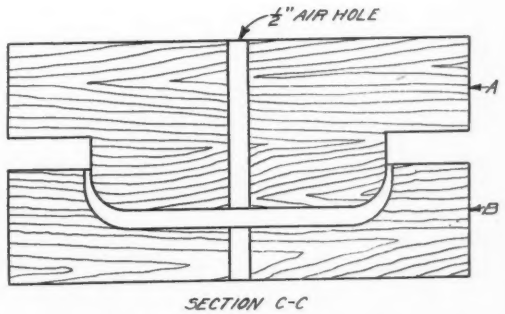
C. P. PAYNE.

Care of Cup Leathers

THE LETTER by C. A. J. in the May 1 issue on cup leathers on hydraulic presses has been noted.

For some years I was trouble man at a factory





MOULD USED FOR CUP LEATHERS

where part of my duty was to keep the hydraulic presses in good condition. These presses were located in different parts of the works and some of them exerted a pressure of 400 tons, being used to press carbons, etc. We cupped our own leathers, varying in size from 8 to 18 in. in diameter.

For each size cup mould we used two pieces of hard wood, turned out as shown in the sketch. These moulds

had been in use some years and were still in good condition when I left the town.

In cupping the leathers, the piece was first cut in a circle 2½ in. greater in diameter than the diameter of the cylinder, or the opening in the wood piece B. After leaving it in slightly warmed water for about 10 min. the leather disk was laid over B and the bottom of A pressed down, forcing the leather into the opening. A heavy weight was placed on top of A, and left there for some hours. If desired, holes could be bored in the blocks and they could be drawn together with bolts and nuts.

This makes as good cup leathers as those made in factories with expensive iron moulds.

Only the best of leather stock should be used for cup leathers.

Some of the cup leathers I have seen in factories were not fit to be used on an ordinary hand pump, being made from leather which becomes soft and mushy when wet.

The cup leathers I made were used on the different presses 8 hr. a day, six days a week, and lasted on an average six months. They received absolutely no treatment with oil, grease, or anything else; care was used to keep all dirt or grit out of the cylinders, but that was all. The water used in the presses was supplied from the city water mains, the water containing no sand or grit.

JAMES E. NOBLE.

Feeding Boilers With Return Traps

SHOWN in the accompanying illustrations are two schemes which I have employed for the feeding of steam boilers by the use of traps. In the case of Fig. 1, but

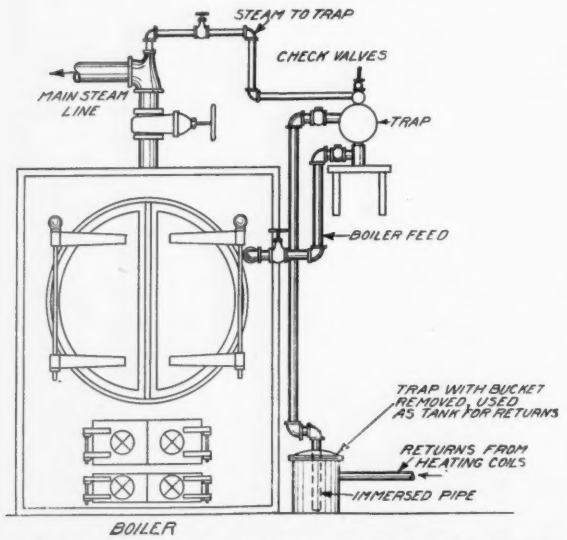


FIG. 1. THE SINGLE TRAP ARRANGEMENT FOR BOILER FEEDING

a single trap, an old Nason with bucket removed, was employed to serve as a receiving tank for the returns from the heating system. This tank was then connected to the trap in the manner indicated, the trap being placed about 4 ft. above the water line of the boiler.

With the arrangement illustrated in Fig. 2, two traps are used. From a return receiving tank the condensate is discharged by the first or lower trap into the upper one from where it passes through the heater and into the boiler.

This double trap arrangement I am at present employing in connection with four 150-hp. boilers and even though three of these are shut down, the traps operate entirely satisfactorily and require considerably less attention than a pump.

I believe the cost of operating these traps is much below that of a steam pump and should they, for some

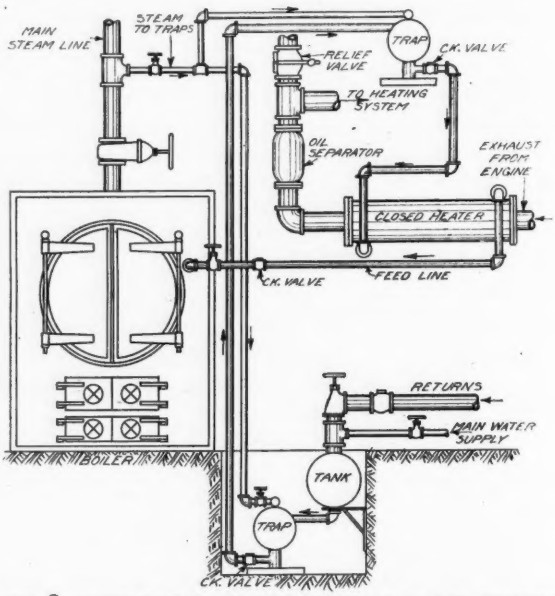


FIG. 2. DOUBLE TRAP ARRANGEMENT FOR BOILER FEEDING

reason or other, become disabled, the cost of repair parts also is much less than would have to be paid for those of pumps.

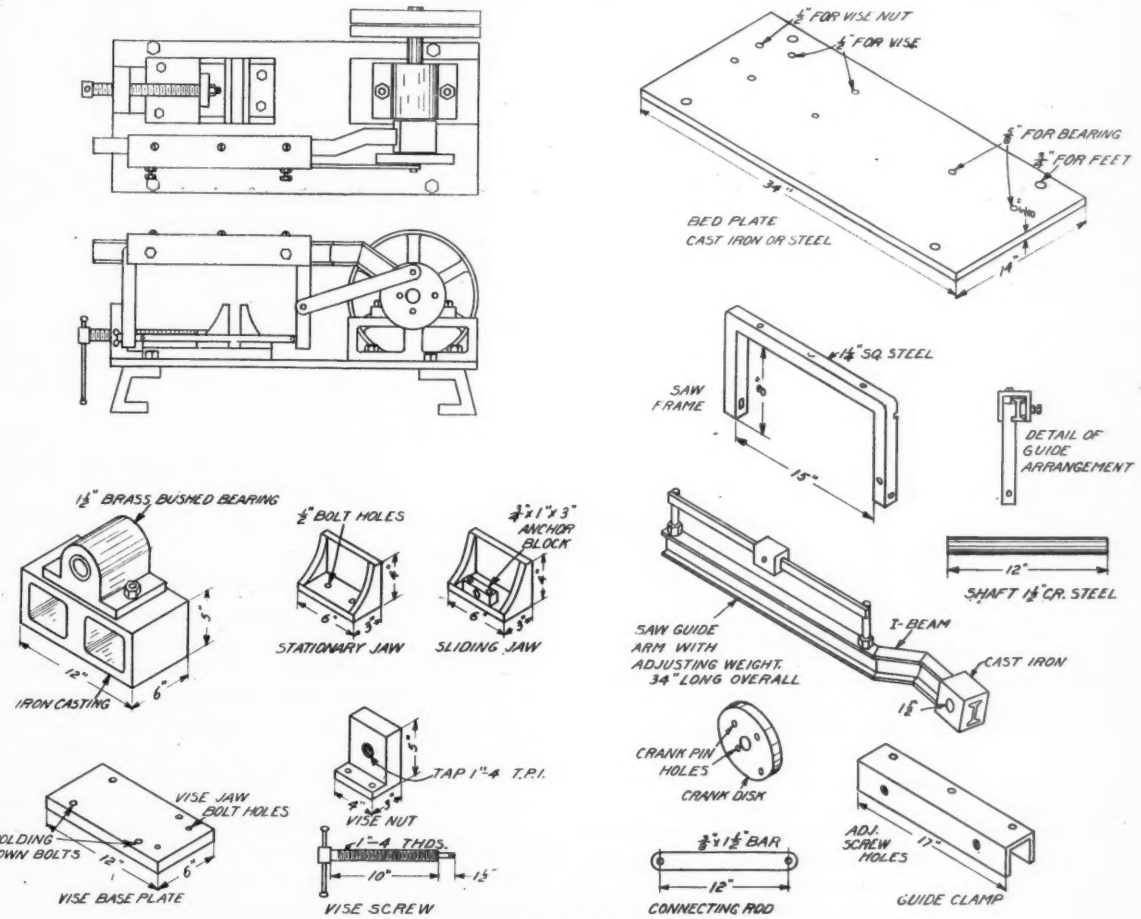
H. ARMSTRONG.

Home-Made Power Hacksaw Machine

IN A small repair shop or power plant, large or small, a power saw is seldom found, as the installing expenses are too large. Such a machine can easily be built, however, and with practically no expense, as the scrap pile generally contains all the parts required.

In the drawings are shown a top and side elevation of the machine complete, and from the detail drawings it will be seen that the bed plate is 34 by 14⅝ in., and the material boiler plate or cast iron. This is the foundation of the machine. The part B is a casting from a machine that has seen its time of usefulness, and so found its way to the scrap pile. This part serves as a support block for the main bearing C, which also comes from the scrap pile. This bearing is faced, bored and fitted with a brass bushing, having a bore of 1½ in. The hole must be absolutely square with the face of bearing, otherwise the saw frame will not run true in stroke. The shaft D is of cast iron or steel 1½ by 15 in. To this shaft is attached the saw frame, which is made of an I beam. The part E is a square cast iron block, which is drilled and filed to allow the beam to be attached, then riveted together; the sides of the block through which the hole for the shaft D is drilled must also be square

with the hole. The tight and loose driving pulleys are 12 in. in diameter, 2 in. face and 1½ in. bore. The saw frame is made of 1¼-in. square iron bar. The connecting link or strap is cast iron. The vise jaws are reinforced angle iron or machine frame supports. The screw is from an old discarded vise. The screw nut standard is of a piece of cast iron. The screw is connected to the vise sliding jaw by means of an anchor block fastened to the jaw by two ⅜-in. bolts. Adjustment is made by the two screws S S, which act against a filler plate. Through this is secured the alinement of the frame.



VIEWS AND DETAILS OF POWER HACKSAW

The complete machine may cost no more than $5 and be equal to a $150 machine, and will prove itself useful every day.

OTTO DORTHEN.

Increasing Back Pressure and Fuel Conservation

ON GENERAL PRINCIPLES we are taught that to increase the back pressure on an engine to such an extent that all of the exhaust cannot be utilized is wasteful. This we know to be true, when we consider that for each pound of back pressure an equal amount of forward pressure is added, which, of course, necessitates a later cutoff and a greater volume of steam from the boiler.

We know, too, that it is impossible to heat water to the same temperature as that of steam used for heating, and that with atmospheric back pressure a temperature of from 208 to 210 deg. F. is about all we can obtain.

A neighboring power plant using artesian well water has a considerable bill each year for boiler compound. Experimenting a bit, the engineer found that by adding 5 lb. back pressure sufficient heat could be put into the feed water to cause much more scale-forming matter to settle in the pans of the open heater, with the result that the boilers are but little scaled and the cost of treatment is reduced.

Shavings and sawdust from the mill were used as fuel, and as the production of these by-products is greatly in excess of the consumption, the company planned on building an incinerator in order to get rid of the surplus. Instead of this, however, upon the recommendation of the engineer, this surplus, instead of being burned, is now being sold to another plant.

The increase in steam consumption due to increased back pressure may be calculated as follows: The engine referred to above, a 16 by 36-in. unit, running at a speed of 100 r.p.m., develops 200 hp. when cutting off at ¼ stroke and with a mean foreward pressure of 57 lb.; this when exhausting against the atmosphere.

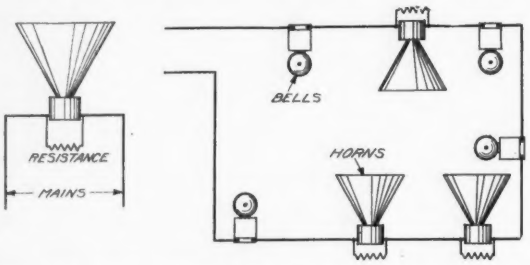
With the exhaust (back) pressure raised to 5 lb., the mean foreward pressurse would then be $57 + (5 - 0)$, or 62, and the steam consumption is $5 \times 100 \div 57$, or 8.77 per cent more than before.

RECEIVER.

Call Systems

On one call system which I had to install several devices were to be used. In some places we had a single stroke gong, in others we used electric horns. The single stroke bells, which were in series in the circuit, did not work satisfactorily with the horns, which were worked upon a make and break principle, which caused the bells to strike several times, and sometimes they did not strike at all.

We endeavored to overcome this objection by shunting part of the current through a resistance, see sketch. As the resistance of bells was not known, we had to make several tests of different resistances before we finally got it right. These horns were originally intended for low voltage, and as we had a series system, this called for a high voltage and considerable current. The shunts that were placed around these horns saved a considerable expense in maintenance, as the platinum points would soon be burnt off and new ones would be



HORN AND BELL CIRCUIT WITH DETAIL SHOWING SHUNT AROUND HORN

required. By varying this resistance the horns could be made to give a very shrill tone or a very dull tone.

Dean B. Cobb.

Fireman's Damper Position Signal

For some months we have been using an electric signal device for indicating main damper position, which works out very well in our fireroom, consisting of four 125-hp. horizontal tubular boilers.

I took an old starting box slate and removed brass contact points, replacing them with three separate brass plates (see sketch) using the old contact lever with carbon contact. I drilled holes and put in connecting screws in slate for the wires to signal lamps, these wires are run through conduit to outlets in engine and fireroom.

Signals consist of three 110-volt 15-watt lamps colored red, white and blue.

Red indicates damper open.

White indicates damper closed.

Blue indicates damper mid position.

The above switch was bolted to breeching and a 3/16-in. hole being drilled through the damper shaft and a lever or crank of suitable radius firmly attached to it. A ⅜-in. pin was tapped into the damper and switch levers having two washers and split pins on each, connected by an insulated rod from damper lever to switch lever.

I find that it interests the real fireman, the fellow worth while, the future B.t.u. economist, to see a visible credit and know that others see it.

The recording gage and the Venturi meter are desirable and helpful parts of the equipment to most of us, but not all of us have them. I know that our firemen pay attention to signals—they are something that any man readily understands.

Give the fireman a chance to advertise his efficiency or otherwise.

The recording gage gives a true reading of steam pressure carried and a good chart is appreciated, but under what damper conditions was the chart maintained, was the red right, the blue or the white on most of the time? Attach a recorder to the lamp circuits and find out, a point surely worth taking into consideration.

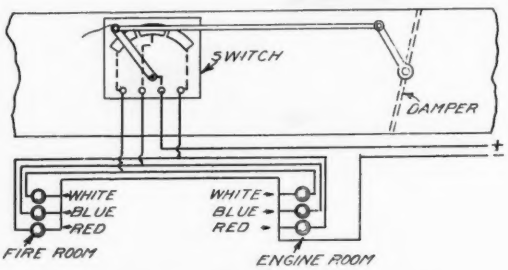


DIAGRAM OF DAMPER POSITION INDICATOR

If a given number of pounds of water are evaporated per hour or 24 hr., per pound of coal, under what damper position was it done?

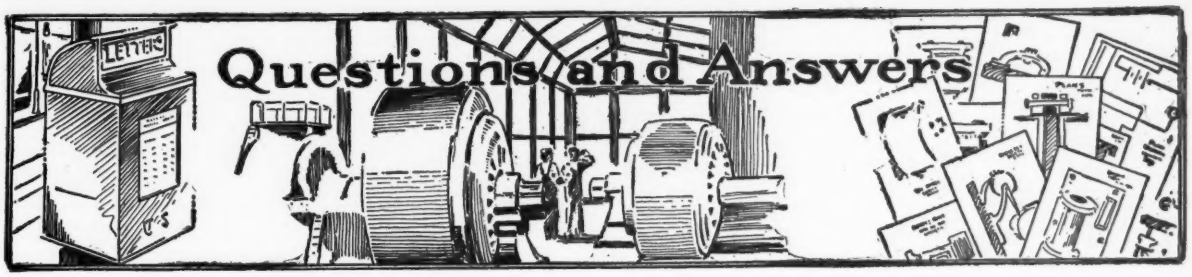
The fact should be worth taking into consideration where a bonus system is used, or conditions of coal consumption considered and noted.

Turner J. Oakley.

Wasted Fuel in Factories

In most factories, ashes and waste from boiler and other furnaces carrying a variable amount of usable fuel is either taken to a common dump or is carted away without any attempt at recovering the useful parts, sifting even not being done. In this way loss of fuel occurs, and it would seem that there is room for treatment of both factory and domestic fuel wastes. Probably a combination of dry and wet separation would give the best results, the material being graded, and to some extent separated dry by means of revolving screws as in a cool washery, and afterward separated in wet jigging or other machines, as far as the heavy waste is concerned, the light stuff-metals, and perhaps rejections from a 2-in. mesh screen being hand sorted. Fine stuff below that pasing a ¼-in. mesh screen could also be left untreated, and the result of treating the grades between ¼-in. and 2-in. would be fuel and waste. Mark Meredith.

After having devoted almost its entire energies toward helping to win the war by giving over to the common cause its experts, that they might through their peculiar knowledge develop new methods of destruction of the enemy, the Bureau of Mines, Department of the Interior, has now returned to its interrupted peace program, and during the week of Sept. 29 next will formally dedicate, to the best interests of humanity, its new million-dollar laboratories and workshops in Pittsburgh, Pa., with ceremonies which will be national in scope.



Oil Engine Lubrication Problem

WE HAVE a 25-hp. Fairbanks-Morse oil engine belted to a 300-gal. per minute centrifugal pump operating against a head of 180 ft. The speed of the oil engine is about 335 r.p.m.

More or less trouble as enumerated below is being experienced with this engine, and if any of the readers of Power Plant Engineering can offer any suggestions tending toward the elimination of our difficulties I would greatly appreciate the information.

In addition to the continual carbonizing of both inlet and outlet ports, we have thus far been unable to obtain any satisfactory lubricating oil. And should we, we are at a loss to know the proper quantity to work through the engine properly to lubricate it, and still prevent the introduction of such quantities as would clog and gum up the ports.

I am quite sure the engine is not overloaded, for, according to measurements, we find the pump to be delivering 240 gal. of water per minute. T. C. P.

A Refrigerating Plant Problem

HAVING USED the same ammonia for six seasons (we operate about 8 mo.), we find it necessary to open our expansion valves to our rooms more every year in order to get our desired temperature, and it also takes more ammonia in our receiving tank to run our plant.

Our plant was first charged with 2000 lb. and in the six seasons we have added 1300 lb.

On account of a leak in our receiver last year, it was necessary to pump our entire charge into our coils and we notice that our ammonia now looks discolored.

What remedy would you suggest? J. L. B.

A. In order to give real remedial advice regarding the troubles in your plant, the general operating conditions should be known.

With the information furnished, it looks like a clear case of a shortage of ammonia and a dirty system.

Look for a small leak that is slowly but surely draining the system.

If the ammonia condensers are of the double-pipe type, examine each inner tube. To do this, shut off the water one stand at a time and remove the water return bends. Do not shut off the ammonia, but allow it to circulate as usual and if the condenser pressure goes up, slow down the machine.

Light a sulphur stick and hold it at the open end of each inner tube. Even a small leak will cause smoke, and this will show plainly if there is a leak. A small amount of pulverized sulphur burned in a hand ladle will be just as good as a sulphur stick.

If the condenser is of the atmospheric type, stop the machine and shut off the circulating water. Then test carefully with burning sulphur. Look over the lengths of pipe as well as the flanges and joints, as small pin holes often develop.

If there is an ice tank or any apparatus with submerged ammonia coils test for leakage of ammonia into the brine. For this testing use litmus paper or Nessler's solution.

To be positive that there is no leakage, examine and test carefully every part of the plant.

Enough liquid ammonia must be in the liquid receiver to show at least ½ of the glass gage full when the system is in ordinary operation.

It is not economy to operate with a small charge of ammonia.

Purge the system for non-condensible gases.

The dirt in the system will consist of scale on the ammonia condenser and oil and moisture in the evaporating coils.

Scale in the inner tubes of a double-pipe condenser prevents a free passage of heat to the water and does not allow for complete liquefaction and cooling of the ammonia.

Test the water going into the inner tubes and also leaving for the temperature difference. If the difference is less than 6 deg. F., it is sure that the water is not receiving its full load of heat.

Scrape the tubes with a stiff wire brush; or, if the scale is hard, a twist drill welded to the end of a length of pipe must be used. In extreme cases it is often cheaper and quicker to put in new tubes than to remove the scale.

On atmospheric condensers the scale can be removed by knocking it off with a light hammer.

Remember that scale is just as harmful on the ammonia condenser as it is in a boiler.

The direct expansion coils in the cold storage rooms are most likely coated with oil on the inner surfaces.

Evaporating coils, whether in an ice tank or in a direct expansion system, must be cleaned internally at least once every 3 yr.

Disconnect both inlet and outlet of each coil and blow high-pressure steam through till the coil is hot; then follow the steam with dry air to remove the moisture.

The installation of an ammonia purifier will prove a good investment in any refrigerating plant.

A. G. SOLOMON.

Re-Use of Wood Battery Separators

THE PLATES of a storage battery which had been badly sulphated were before being replaced in service thoroughly washed with distilled water.

Would you advise the re-use of the wooden separators which had been previously employed or do you think new ones ought to be used? V. K. S.

A. There is no objection to using the wood separators in the storage battery after they have been in a battery which has been washed out thoroughly. Of course, if these separators are decayed or crumbling, they should not be used, as it will be but a short time before they will be likely to break down and cause a short circuit, and the cost of new separators is much less than that of opening up the battery to take care of such a breakdown.

If, however, the separators are new or in good condition, the mere fact that they have been in the battery while it was being washed out will do no particular harm. If the battery has been badly sulphated, it would be well to take out the plates and the separators and make sure that all sulphate has been removed from both plates and separators before the battery is assembled and recharged.

Mean Pressure vs. Mean Effective Pressure

To DETERMINE, under given conditions, the mean pressure of expanding steam in the cylinder of an engine, proceed as follows: For example, let us assume that the initial pressure by gage is 80 lb. and cut-off takes place at ¼ stroke. Draw horizontal line V V as in Fig. 1. Make this any desired length, but remember that it represents the stroke of the engine. The initial pressure is 80 plus 15 or 95 lb. abs. Suppose that a 50 scale of spring is adopted. Then measure off 95 lb. with it at right angles to line V V, which represents a perfect vacuum. This gives the correct height of a theoretical diagram for given conditions. From this point draw a line parallel to V V and one-quarter the length of it, marking it S S; this represents the steam line. From the end of this line draw another in the form of a perfect hyperbola until it coincides with the length of V V. Mark this E E, as it is the expansion line. Only these three lines are used in determining the mean pressure of expanding steam.

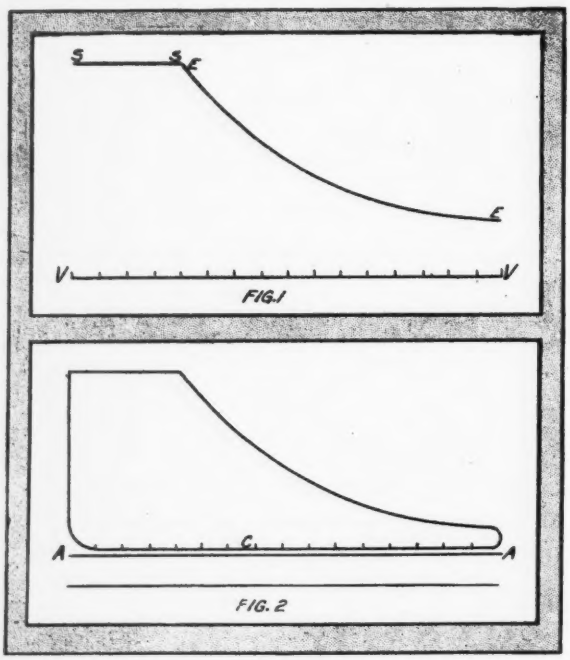


FIG. 1. CONSTRUCTION OF DIAGRAM FOR DETERMINATION OF MEAN PRESSURE

FIG. 2. SHOWING METHODS OF DETERMINING MEAN EFFECTIVE PRESSURE

The next move is to determine the average height of S and E above V when measured with a No. 50 scale. It is not necessary to lay off the diagrams into 10 spaces, as any number may be used. For this purpose we may place dots on the vacuum line ¼ in. apart. Measure from each dot to the line above it, note the results in a column, add them and divide by the number of measurements taken. The quotient will be the mean pressure of expanding steam for stated conditions. In this case, the answer is 56¾ lb.

Rather than take the time to follow the above-mentioned rule, it is better to refer to a steam table for the answer. My object in presenting the foregoing is to show how these tables are constructed, and to enlarge upon the principles involved, which are not always understood.

There is a table before me that bears the following inscription: "Average pressure of the steam upon the piston throughout the stroke." By taking the column under 95 and following it down to the horizontal line representing ¼ stroke, the answer is 56¾ lb. average, or mean pressure. Some of the published rules for determining the power of an engine tell us to use the average pressure; but this is not correct, because it gives a greater quantity than can be realized.

The mean effective pressure must be used for this purpose, and Fig. 2 illustrates a rule for finding it. Draw the lines explained for Fig. 1, and add line A A, which must be 15 lb. above the vacuum line. Assuming 1 lb. back pressure by gage, locate counter pressure line C 1 lb. above A. The end lines may be drawn to complete the diagram. The average height of the diagram above C when measured with a No. 50 scale is 40¾ lb.

By referring to the above-mentioned rule, we find that the mean pressure is 56¾ lb., and subtracting 15 plus 1 or 16 lb., absolute back pressure gives a mean effective pressure of 40¾ lb. Therefore when estimating the power that an engine can develop with an initial gage pressure of 80 lb. cutoff at ¼ stroke and 1 lb. back pressure by gage, it is proper to assume that the mean effective pressure is 40 lb. or one-half of the initial pressure.

My purpose in this article is to show an error made in question 24, on page 426 of May 1 issue. The author of this question and answer is evidently somewhat confused, as the mean pressure and the mean effective pressure are never the same. W. H. WAKEMAN.

In Trouble

RELATIVE to the communication of A. Owl, appearing on page 424 of the May 1 issue, quite a number of our states already require engineers in charge of plants to have a license of a grade depending upon the size of the plant. However, I believe the matter could be more quickly brought to a head in a national way if each and every one of our engineering societies would

take up the question directly with their senators. By that method it could be made a universal law more quickly than any other way of which I know.

In reference to operating conditions in the South as compared with those existing in the North, East and West, I am of the opinion that the conditions, after summing them up as a whole, are in reality about the same. Some plants are better managed, which means easier working conditions to all, and those that are not are not very pleasant to be employed in.

In reference to the night and day engineer, I presume that he is referring to a plant of small size, for, as a rule, in plants that run night and day there is not only an operating engineer on the day shift and one on the night shift, but also a master mechanic or a combined master mechanic and chief engineer, who has charge of the plant and gives the plant the necessary attention at night, although he spends most of his time on the day shift. If he is the proper kind of chief engineer he will alternate his operating engineers every two weeks or once a month, as they desire; and if it is a small plant, where the chief is taking one of the operating runs, and has any spark of feeling in him for his work fellow, he will either take one week in a month, one night in a month or two weeks in a year in the night man's place.

In reference to a chief engineer who never reads a trade magazine or book of his trade, all I have to say is that he is not only a dead one, but a stumbling block in the way of progressiveness. H. W. ROSE.

Examination Question Comments

THE 12TH QUESTION, on page 425 of the May 1 number, asks the candidate to state all the advantages of a steam dome.

Would it not have been advisable to ask about the disadvantages also? I was under the impression that steam domes were seldom, if ever, used on new high-pressure steam boilers, in stationary power plants, at the present.

There are other and better ways to secure "the advantages," as given in the answer. The dry pipe is just as useful in obtaining dry steam as is the dome. The one thing to attend to in installing a dry pipe is to see that the total area of the perforations is much greater than the area of the steam main. As the dry pipe usually extends along a considerable distance in the steam space, it thus draws steam from a large portion of the steam space, there is no rush of steam from any one section of the water surface. Its principal advantage over the steam dome is in the fact that its attachment does not weaken the shell to any appreciable extent. In the case of the dome, the shell of the boiler is cut away, thus removing a large amount of solid plate, making the boiler considerably weaker under the transverse strains set up, and also permitting greater distortion.

JAMES E. NOBLE.

QUESTION 22, on page 426 of the issue of May 1 reads as follows: "What is the effect on an engine if the exhaust is liberated too soon?"

The answer given is not correct, as this fault has no effect whatever on compression as is claimed. If the expanded steam be allowed to escape before the stroke is completed, the forward pressure is slightly less than it otherwise would be, but this may be partially or even wholly offset by a reduced back pressure. If the load is heavy, causing a high terminal pressure, it frequently prevents the steam from escaping freely, hence the back pressure will be high at the beginning of the return stroke. Even this cannot affect the compression, as that takes place on the other side of the piston.

In the last column on page 427 the following statement appears concerning a shifting eccentric on an automatic engine: "A device of this kind makes it possible to use the simple slide valve, and at the same time secure a variable cutoff in governing the speed of the engine."

There is not an engine on the market today that utilizes a simple slide valve in connection with a shifting eccentric or shaft governor. The reason for this is the fact that a simple slide valve is not balanced, hence its friction is so great in practice that the governor cannot shift it to meet changing conditions. Flat valves are used, and they slide; but they are not of the simple kind, because some device must always be used in connection with them to prevent unbalanced pressure, and this takes them out of the simple category and makes them more or less complicated. Some of them are much more complex than their appearance indicates.

The Meyers valve and gear, also the link motion on a locomotive, are variable cutoffs because they can be varied by hand, while the engine is in service; but the ordinary high-speed engine with a shaft governor is an automatic cutoff. The two types are distinctly separate and should not be confounded. W. H. WAKEMAN.

Why the Receiver Pressure Drop?

WITH REFERENCE to the inquiry of J. M. K., appearing in the May 1 issue, relative to the drop in receiver pressure, it appears to me as if his trouble must be due to the fact that first his low-pressure cylinder is consuming more steam than the high-pressure cylinder is putting into it or, in other words, first we will acknowledge that his valves are set correctly in the high-pressure cylinder, but the low-pressure live steam valves are not cutting off early enough, which causes the receiver pressure to remain low, and at the same time the bulk of the work is being done upon the high-pressure cylinder, and practically no power at all is being generated from the low-pressure cylinder, so shortening the cutoff on the live steam valves of the low-pressure will not only increase his receiver pressure, but will more easily balance the load upon both cylinders.

An authoritative writer made the following statement: "The receiver pressure also has something to do with the position of the governor. The receiver is usually a plain metal cylinder placed beneath the engine room floor, and to which the exhaust pipe from the high-pressure cylinder, and the steam pipe to the low-pressure cylinder are connected. The high-pressure cylinder exhausts into the receiver, and the low-pressure cylinder takes its steam from the receiver." It will be understood from this that the receiver virtually serves as a boiler for the low-pressure cylinder. The pressure in the receiver is generally a little lower than the terminal pressure in the high-pressure cylinder, while the receiver pressure and the initial pressure in the low-pressure cylinder are practically the same.

H. W. ROSE.

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Zone Subscription Rate July 1

It has been the hope of the publishers of Power Plant Engineering that the vicious Zone Postal Rate for periodicals would be done away with, so that it would not be necessary to establish zone subscription rates. Up to the present time, therefore, the excess cost of mailing to distant zones has been paid by us. But there has been no change in the law, and as another big increase in the zone rate of postage goes into effect on July 1, it has become necessary to take action in accordance with the plan advocated by the officials of the Postoffice Department.

Based upon the increase in the Zone Rate, the subscription price of Power Plant Engineering will be $2 a year in the 6th, 7th and 8th zones, beginning June 30, 1919, at 12 midnight.

Your Most Important Problem

During the reconstruction period, power plants will have to meet many problems which are entirely new to them. In some localities, the labor problems will undoubtedly be the most important to solve. Fuel, freight rates, delivery of new equipment, selection of proper equipment, keeping an overloaded plant running until additional machinery can be installed—any of these or others may be your most important problem. The editors of Power Plant Engineering wish to know just what yours is, for the purpose of putting in your hands information that will lead to the correct solution, also presenting the information to others in anticipation of their meeting with similar difficulties.

Cool Water to Drink

With summer and warm weather at hand, the power plant is not called upon to furnish heat for the comfort of occupants of buildings; but the demand for cool drinking water will increase continually until the heat of summer has passed. To supply this drinking water is becoming more and more the duty of the power plant as refrigerating machinery becomes more popular for such work.

To perform such a service as supplying healthful drinking water at a reasonable cost requires considerable planning and calculation, but several systems have been devised which work satisfactorily and it is to acquaint our readers with these systems and how to calculate requirements that we publish the article by Mr. Hubbard on page 489. The old-fashioned ice water tank and public drinking cup have passed and in their places have come pure drinking water, cooled to the most healthful temperature without becoming contaminated with disease germs, and the sanitary drinking fountain conveniently located in various offices, hallways and departments. Providing pure drinking water is a welfare work well worth establishing in every office and industrial building.

Progress in Stoker Design

Because central stations manufacture power for sale, they have given more attention to the economical development of power than any other class of power plants. Industrial power plants usually have a different class of

service to perform than central stations, but a study of the methods used in the most successful plants is sure to reveal some feature that can well be adapted to even the most special industrial plants.

The unusual fuel conditions which have existed during the past two years have been the cause of considerable change in the equipment employed in some of the most prominent power plants of the country, as brought out by Mr. Worker on another page of this issue. The changes which have taken place are gradual improvements in details which experience has indicated as advisable. Thus we have, with the underfeed stoker, the automatic clinker grinder, control board at rear of boiler, air boxes in side walls, curved end of grate, and several other features, small in themselves, but each a step in advance of former designs.

Filling a Gap

Many of the best operating engineers are striving for the position of chief engineer where such a position carries with it a seat in company with the heads of departments of an industrial concern with executive and buying power in addition to responsibility for the safe and economical operation of the machinery of the plant. The strife is often bitter, frequently the goal is thought to be within reach after long years of hard and faithful toil, he is next in line of promotion, but the position which he considers should be his is handed to another with less experience and younger in years. Ye Gods, what a disappointment!

He talks of favoritism, pull, bluffing, hynotism, concludes to resign because he cannot get fair treatment, then decides he had better get another place first. He hunts, is successful in locating where his work compares favorably with what he had, but thinks prospects better. Again he starts with enthusiasm, but his hope is met with a blight once more. He sees a gap, an apparent chasm, he has met it time and time again, he sees others pass over apparently with ease, but to him it is impossible. Why?

He quizzes himself. No part of his plant has not been mastered. He never has accidents due to lack of care. His machines are in the pink of condition. He concludes that his engineering is without criticism, yet a chief's position is denied him at every turn.

This is a common story, not alone in engineering, but in every walk of life, and the solution is not alone in mastering the mechanical or clerical situation, which must, of course, be done, but in addition becoming master of the human element with which you are surrounded. The chief engineer's work is largely in dealing with men, securing from them their best work and co-operation, in judging the character of the men when he employs them, in dealing impersonally and without sentiment when making purchases, in influencing his superiors to think as he thinks when their aid is needed to accomplish desired results. All these and many more human problems are presented to the chief engineer.

There is a wide gap between the positions of operating and chief engineer and to bridge this gap requires as much if not more study than to master the details of machinery construction and operation. The difficult part in the training is the change one must frequently make in his own character in order to make it harmonize with his human environment. Time spent in self-analysis after each failure to secure exactly what you desire from others is exceedingly well spent if the shortcomings discovered are corrected.

Engineering education should include not only mastery of technicalities of the profession, but a thorough understanding of human nature which has been sadly neglected in the past. It is interesting, therefore, to note some of the remarks of Professor Bass at the recent convention of the American Association of Engineers, who pleads for a broader education for engineers than is contained in the ordinary curriculum. We quote the following:

"Engineering education must meet the demands of the engineering profession, not only those demands which have been given definite form, but also those which now inarticulate, are struggling for expression. Professions come into being in response to great human needs, and are endowed with vitality and life in proportion as they minister to those needs. The engineering profession is youthful, it has lavished the service of its constructive genius upon a waiting world and a new order of civilization has evolved with a rapidity unknown in other ages. Men have been given suddenly, within a few score of years, new wealth and power which has brought their minds into contacts a thousandfold multiplied beyond previous experience. In the last four fateful years new groupings have been formed in unforeseen environments with still further acceleration. The world is now confronted with the problem of quickly adjusting itself to the conditions which are inexorably imposed upon it.

"We can all agree that no clear, virile, determined declaration has come in unison from the profession, for it is relatively young and does not yet know its place in the world, it has not had the experiences and grapplings with life that alone can teach its true place, its duties, its privileges, its limitations and its power. Time and trial will bring it to a realization of these, a realization that will be splendid and magnificent.

"The first requirement in teaching or in any other form of directing men's minds and hands is to give to them a clear, definite objective, and so it is that the greatest factor in intelligent, fruitful and efficient teaching lies in supplying the motive force, a reward for accomplishment. Given that, the problem of teaching is one of direction and not one in which the teacher must use his energy in forcing unwilling minds to grasp ideas, theories, applications of theories and facts which seem to be devoid of interest. A foreman or superintendent who must continually with his own hands do the work of his gang or his force is not the man to produce results. He must keep his attention on all his own and their tasks, encouraging, checking, taking advantage of occurrences and co-ordinating the efforts of all. So must the teacher work, and his students, like the men under the foreman, must receive the inspiration of a clear objective and definite progress toward it, even though the objectives be unlike in character and in degree of remoteness. The engineers of America hold in the hollow of their hands the future of their profession. Let them set the mark, let them demand results from schools, let them lead and they shall not be disappointed in their followers who themselves, some still better day, shall be the leaders."

Electrical Equipment for Mine Pumps

THE MOST essential requirements of mine pumps, that they run continuously and take as little power as possible, are met by a complete line of electric motors and control built for all sizes and commercial circuits, either alternating or direct-current. In addition to these the advantage of lower first cost and maintenance expense, greater compactness, flexibility and ease of control inherent with electric drive are obtained.

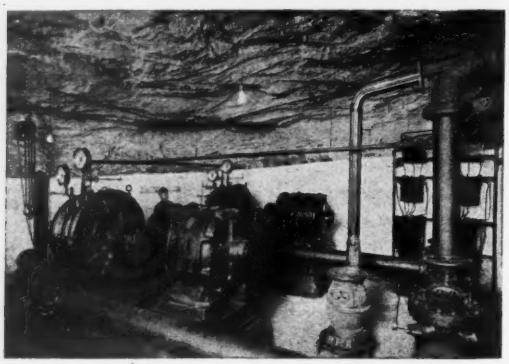

FIG. 1. TWO 100-HP. SQUIRREL-CAGE INDUCTION MOTORS COUPLED TO 6-IN. 3-STAGE CENTRIFUGAL MINE PUMPS

Simplicity and ruggedness of the squirrel-cage motor make it especially adapted to mine pump service as it is built largely of steel and has nothing to wear except the bearings which are large, well lubricated and require but little attention. These motors may be started at the machine or at a distance. When started at the motor those smaller than 7½ hp. use a simple fused knife switch and the larger ones require hand-operated

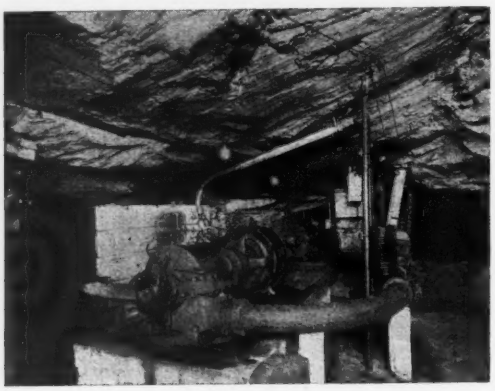

FIG. 2. TWO 200-HP. SQUIRREL-CAGE INDUCTION MOTORS COUPLED TO CENTRIFUGAL PUMPS

auto-starters. When started from a distance an automatic starter is used, of the resistor or auto-transformer type, which gives thorough protection and operates at high efficiency at both speeds. Only a simple double-throw switch is required to change from one speed to the other.

If the power source is limited or a speed reduction is at times desired, the wound-motor type motor with the same general mechanical characteristics as the squirrel-cage motor, is furnished. With this motor also, either hand-operated control at the motor or automatic control at a distance may be used.

Many mines have only direct current available and for these standard motors having the same, simple, strong and reliable construction, steel frame and rugged bearings are used. These motors are built self-starting as large as 20 hp., so that they may be thrown directly on the line from any desired point. For pumping from a sump, a float switch in connection with an automatic controller will start and stop the motor at the desired limits.

An especially handy outfit and an efficient arrangement of pumping equipment is obtained by mounting a motor-driven pump on a truck or mine car. This will enable quick transportation of the pump to any necessary location.

Electric motors for mine pumps of either alternating or direct-current type are mechanically and electrically designed to give continuous, dependable and efficient service with little attention for long periods of continuous operation. Where necessary additional protection may be added by enclosing the motors or supplying especially treated insulation to protect them from grit or dampness.

News Notes

THE HEINE Safety Boiler Co. is fortunate in securing the services of Chas. H. Stoddard as its consulting marine engineer. Mr. Stoddard is a native of California. He received his technical education at Stanford University, specializing in mechanical engineering, where he was a member of Pioneer class, 1891-1895. This is the same class that turned out Food Administrator H. C. Hoover and Will Irwin, who writes from France for the Saturday Evening Post.

From 1895 to 1900, he was employed in shops and drawing rooms in Cleveland, Ohio, and Pittsburgh, Pa. Then returning to the Pacific Coast he entered the drawing room of the Union Iron Works of San Francisco. He was chief engineer of the Fulton Iron Works and of the Risdon Iron Works of San Francisco, and for nearly three years was civilian superintendent of shops at Mare Island Navy Yard.

On Jan. 1, 1916, he went to Moore & Scott Iron Works and held the position of chief engineer of that company, now called the Moore Shipbuilding Co. He assisted them in their expansion from a repair shop employing 250 men to a shipyard with 9500 men on their payroll holding contracts for 42 steel cargo boats for the U. S. Emergency Fleet Corporation.

Probably no shop of today would attempt to build so great a variety of machinery as the Pacific Coast shop of from 10 to 25 yr. ago. There was nothing too big or complicated for the Pacific Coast shop to undertake, consequently few men have been called upon to take the responsible part in the designing of so great a variety of machinery as Mr. Stoddard. Boilers of all types as well as engines of all types and sizes, mining hoists and mining machinery, steamers of various kinds, tugboats, stern-wheelers, side-wheelers, warships and cargo boats. With all of these he has been in very intimate contact. In co-operation with E. A. Rix he designed

three of the largest air compressors ever built in the United States. Previous to the San Francisco fire in 1906, he designed and built a dozen cross drum Heine marine boilers and these are in operation today on the Pacific Coast and giving the greatest of satisfaction. It was his experience and intimate acquaintance with the performance of these boilers that made of him an enthusiast for the Heine marine boiler of today, and it

was also because of this intimate acquaintanceship and his vast experience in things mechanical and particularly marine that led the Heine Boiler Co. to secure his services and place him in charge of its marine department.

DR. ARTHUR A. HAMERSCHLAG, President of the Carnegie Institute of Technology, has just issued his annual report to the trustees of the institution. This report deals with the work of the past year and is occupied largely with the share that the Carnegie Institute of Technology had in the education of men for the various branches of war service.

From April, 1918, to Christmas of the same year, 7650 soldiers and sailors were trained in the Pittsburgh institution. At the time the armistice was signed, there were on the campus nearly 2700 men. At the present time, of all the special activities that were inaugurated during the war, there remains only the school for Turbine Engineers that was opened to fit naval officers to qualify as Chief Engineers in the new American Merchant Marine. It is doubtful if any educational institution in the country did a larger work in educating men as soldiers and sailors.

President Hamerschlag, during the war, acted as Chief of the Bureau of Industrial Research under Quartermaster General Goethals.

R. SANFORD RILEY, President of the Sanford Riley Stoker Co. and the Murphy Iron Works, has returned to his private interests after having completed the organization of a performance section of the Emergency Fleet Corporation. The performance section has charge of all trial trips and follows up the defects developed in service. It is now a large and important section of the Emergency Fleet Corporation and its personnel consists largely of engineers who, like Mr. Riley, had formerly followed the sea.

F. A. BEAN, consulting engineer, has recently accepted a position with the Wayne Oil Tank & Pump Co., for whom he will take charge of a new department known as the Consulting and Advisory Service for Oil Men. Mr. Bean has had a broad engineering experience covering a period of 23 yr., 15 of which have been in an executive capacity. He first became affiliated with the oil industry in 1902 in the Kentucky and Oklahoma fields. For the past year and a half he has been at the head of the maintenance and equipment department of the Sinclair Refining Co., and also had charge of the designing and construction of their sales branches and filling stations. He has also been closely associated with the automobile industry and his knowledge along these lines should be of great assistance to oil men in the purchase, operation and maintenance of their rolling equipment.

There is to be no charge connected with the service of this department. This service should appeal to all oil men, especially the marketers and jobbers. The Wayne Co. invites all oil men to make free use of this service.

The functions of service are the standardization of equipment, economical operation and maintenance of equipment, designing and planning of buildings, ground layout, etc.

BENJAMIN G. LAMME, chief engineer of the Westinghouse Electric and Manf. Co., on May 16, was awarded the Edison Medal by the American Institute of Electrical Engineers for "invention and development of electrical machinery."

The Edison Medal was founded by an association composed of friends and associates of Thomas A. Edison and is awarded annually for meritorious achievement in electrical science, electrical engineering, or the electric arts. The award of this medal is one of the highest honors that can be conferred upon an American or Canadian electrical engineer and among those who have received it are George Westinghouse, Elihu Thompson, Frank J. Sprague, Alexander Graham Bell, and Nikola Tesla.

This honor to Mr. Lamme follows closely his appointment to membership on the Naval Consulting Board. This appointment by Secretary of the Navy Daniels also emanated from the recommendation of the American Institute of Electrical Engineers consisting of 10,000 members and constituting one of the largest associations of the kind in the world. Such recognition is of the highest possible rank and establishes Mr. Lamme's position as one of the world's most eminent engineers and inventors. He was chairman of one of the important committees whose work had far reaching results in the prosecution of the war.

THE AMERICAN STEAM CONVEYOR CORPORATION, Chicago, announces the appointment of N. B. Stewart as District Representative in charge of its St. Louis Territory. Offices have been opened at 708 Merchants-LaClede Building, St. Louis, Mo.

THE FIFTH Annual National Exposition of Chemical Industries will this year be held in Chicago at the Coli-

seum and First Regiment Armory during the week of Sept. 22, and as usual there will be a number of society meetings held jointly with it. It is an encouraging sign that the American Institute of Mining Engineers is among the number. It is hoped that this contact between the mining engineers with things chemical, chemists and chemical engineers will be to their increasing and mutual advantage.

OFFICERS ELECTED at the fifth annual convention of the American Association of Engineers held in Chicago May 12 and 13, are as follows: President, F. H. Newell; first vice-president, W. W. DeBerard; second vice-president, T. A. Evans; director to fill vacancy, C. H. Crawford; directors, W. W. K. Sparrow, P. E. Harroun, R. Burnham, F. D. Richards, A. A. Matthews, E. F. Collins.

GEO. D. B. VAN TASSEL, recently sales engineer of the Chicago office, has been appointed to act as Detroit district sales agent for the Power Specialty Co., operating in the territory of eastern and southern Michigan and western Ohio.

THE BOSTON, MASS., offices of the Chicago Pneumatic Tool Co. have been removed to 182 High Street. F. S. Eggleston, district manager of sales, represents the company's interests in this territory. A complete stock of repair parts will be carried at this point, insuring prompt service to customers in this territory.

ROLAND B. PAGE has recently been appointed Eastern District Manager for Lea-Courtenay Co. His new offices are at 810 Broad Exchange Building, Broad and Franklin Streets, Boston, Mass. Mr. Page was for 8 yr. with the Factory Mutual Fire Insurance Co. and the last 4 yr. has been engineer for the Philadelphia Mutual. His familiarity with pump conditions and fire protection methods and service will prove of value to the plant managers of New England who have the opportunity to avail themselves of his experience.

THE HILLS-MCCANNA CO., of Chicago, has recently been purchased by A. H. Noyes and A. H. Smith. Mr. Noyes, who takes the position of president of the company, was formerly secretary and treasurer of the Ayre & Lord Tie Co., while Mr. Smith, who is now secretary and treasurer of the Hills-McCanna Co., was formerly associated with the Sefton Mfg. Co., and brings to the company a technical training and experience. The Hills-McCanna Co. was organized before the Chicago fire as the North Side Brass Foundry, but changed its name a number of years ago when patterns on a forced feed lubricator were developed.

A. E. HITCHNER has been appointed manager of the Mining Section of the Industrial Sales Department of the Westinghouse Electric & Manufacturing Co. with headquarters at East Pittsburgh, Pa. Mr. Hitchner is a graduate of Rutger's College, Class of 1904. He served a two-year apprenticeship with the Baldwin Locomotive Works, and spent three years with the Link Belt Company on construction work before joining the Westinghouse sales organization as industrial salesman in their Philadelphia office in 1909. In 1912 he was sent as sales representative to the anthracite coal field and placed in charge of the Wilkesbarre office, where he has gained an intimate knowledge of coal mining and mining methods. In his new position Mr. Hitchner will handle the sale of all apparatus made by the Westinghouse Co. for use in the mining industry.

THE STOCKHOLDERS of the Joseph Dixon Crucible Co. held their annual and regular meetings on Monday, April 21. The following officials were elected. Directors—George T. Smith, George E. Long, William G. Bumsted, Edward L. Young, J. H. Schermerhorn, Harry Dailey and Robt. E. Jennings. Officers—George T. Smith, president; George E. Long, vice-president; J. H. Schermerhorn, vice-president; Harry Dailey, secretary; William Koester, treasurer; Albert Norris, assistant secretary and assistant treasurer.

The American Graphite Co., incorporated under the laws of the State of New York, is a subsidiary of the Joseph Dixon Crucible Co., and its annual election was held on the same day as that of Joseph Dixon Crucible Co., and resulted in the election of the following officers: George T. Smith, president; George E. Long, vice-president; J. H. Schermerhorn, treasurer; Harry Dailey, secretary; William Koester, assistant secretary and assistant treasurer. The directorate is the same as that of the Joseph Dixon Crucible Co.

The company also announces the removal of its Philadelphia sales office from 1020 Arch St. to Rooms 801 and 802 of the Finance Building, South Penn Sq., Philadelphia, Pa., May 1.

THE SMOOTH-ON MANUFACTURING CO., Jersey City, N. J., has just issued a new and revised edition of Instruction Book No. 16.

The new edition, like its predecessors, is made up of helpful and interesting descriptions of engine and boiler-room repairs of all kinds. These are described by the men who made them in such a way that similar problems can be quickly and economically solved by other engineers. The book is well illustrated by actual photographs and drawings.

LIBERTY MFG. CO., Pittsburgh, Pa., has just published a new Catalog Z covering its product. This catalog contains 40 pages of hints on use of boiler tube cleaners and care of boilers, and will be furnished to anyone interested on request.

FOR THE purpose of furnishing bent boiler tubes for any make of vertical water tube boiler, there has recently been formed The American Tube & Pipe Bending Co. with plant and offices located at Cleveland, Ohio. The prime object of this company is to furnish bent boiler tubes direct to the boiler user, approaching the matter from the boiler manufacturer's point of view to insure absolute accuracy in the bending of the tubes. The active head of the company is A. Wasser, secretary and treasurer. Mr. Wasser was connected with the Erie City Iron Works for thirteen years, both in their factory and in their Pittsburgh sales office, and is thoroughly familiar with practical boiler construction. The company is now installing its bending machinery and will shortly be in shape to take care of the requirements of the trade. The bend is made cold on machines especially designed for the purpose and available for all sizes and bends.